Summer Meeting Issue

SAE journal

IN THIS ISSUE . . .

Pyroceram — New Glass-Ceramics 34

Traffic Paces Brake Development 37

Small Car Case Study 40

Solid Propellants for Rockets 48

Trends in 1958 Truck Design . . . 29

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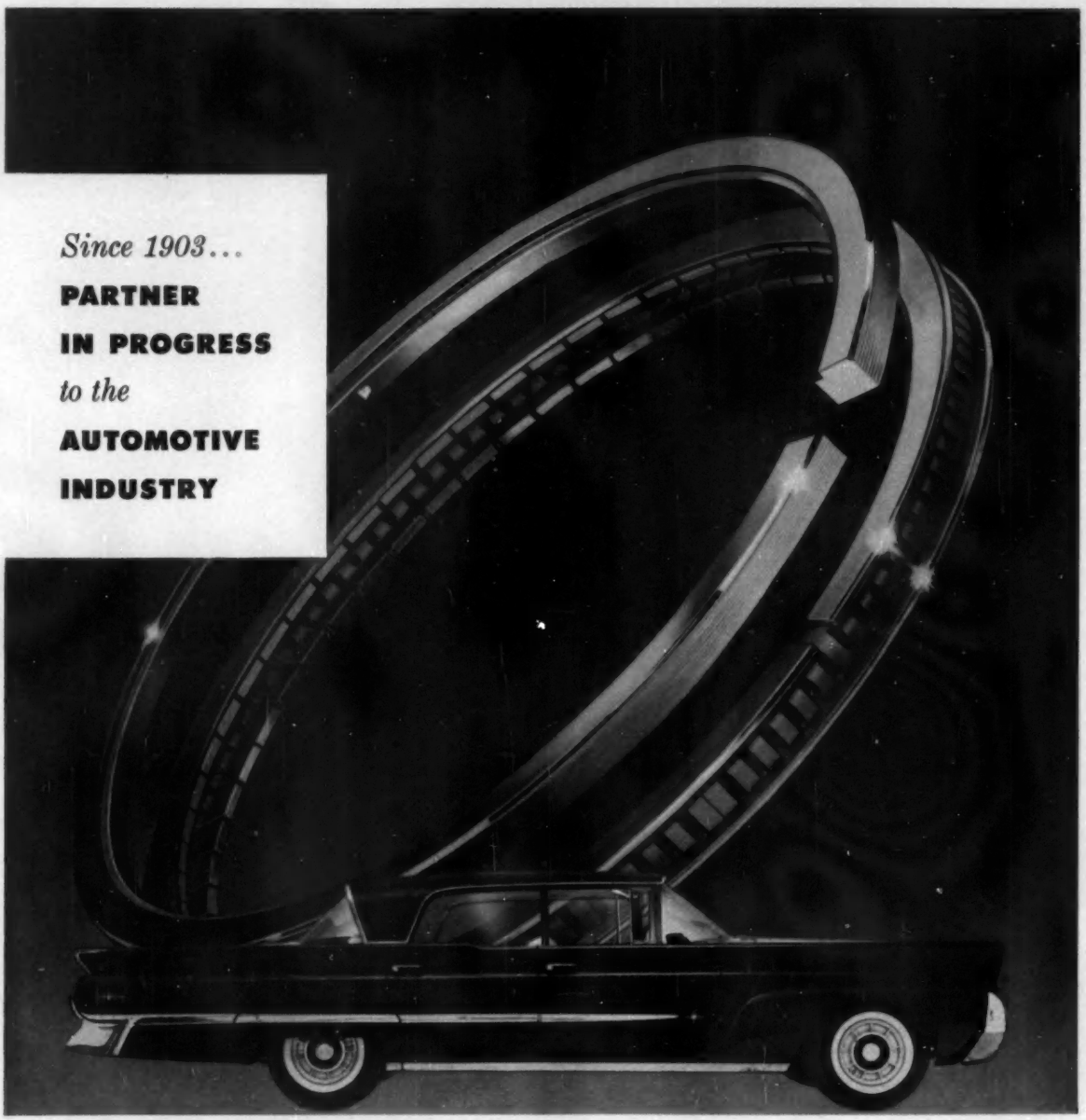

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Pub. Off.: 10 McGovern Ave., Lancaster, Pa.; Ed. Off.: 485 Lexington Ave., New York, N. Y.

Contents • July 1958

READERSHIP RESEARCH

Chips 25
. . . from SAE meetings, members and committees.

SAE Summer Meeting Reported 26
There was no recession in the depth and breadth of technical talk at the 22 sessions of SAE's Summer Meeting in Atlantic City.

Pyroceram 34
Pyroceram signifies a new family of fine-grained crystalline materials called glass-ceramics. These materials are made by controlled crystallization from special compositions containing nucleating agents. (Paper No. 60C) — **Dr. W. W. Shaver** and **Dr. S. D. Stookey**

Sandwich Structure for Wing Panels 36
B-58 Wing Panels are a sandwich of glass-fiber honeycomb between aluminum sheets. Resultant structure is very light, very stiff, very strong, and does not buckle under the high temperatures imposed by aerodynamic heating at supersonic speeds. — **T. G. Pownall.**

How to Design Better Brakes 37
Brake Development paced by traffic needs. Design controls input; maintenance controls output, and both are headed for improvement. (Paper No. S82) — **William Tauss**

Modulator Reverser for Jet Control .. 38
Divorcing the reverser control from the power control gives in-flight and landing-roll reverse thrust. (Paper No. 49C) — **John Burnett** and **Donald Moses**

Well, What About the Small Car? .. 40
When attempts were made to incorporate as many features as possible into a small car design as a case study, three main characteristics were found to take precedence: the fun factor, short-distance driving needs, and prestige value. (Paper Nos. S95, S97, and S96) — **Alan P. Anderson David L. Cohoe** and **Robert F. Jenson**

Powder Metallurgy Comes of Age ... 44
Perfection of the powder metallurgy process over the years now permits precise, high strength, high quality steel parts to be made by this method. (Paper No. 36B) — **Robert Talmage**

Solid Propellants for Rockets 48
Now that we know how to make solid propellants for large rockets as well as for small ones, can large solid rockets compete with liquid units? The answer depends on the application, as discussed in this article. (Paper No. 42A) — **G. S. Sutherland**

Low Maintenance Turboprop Engine 55
Allison 501-D13 Turboprops complete 1000 hr of simulated airline service without overhaul. Utilization averages 12 hr per day. (Paper No. 45B). — **Fred H. Steuber**

New Automatic Truck Transmission .. 56
International Harvester's new automatic type truck transmission has shown good fuel economy and low maintenance costs. (Paper No. S83) — **R. E. McAfee**

Jet-Driven Lifting Rotor for VTOL 59
Jet-driven lifting rotor is a logical method of giving an airplane VTOL capability that has not yet received the consideration it deserves. — **Kurt H. Hohenemser**

TJ38 Zephyr Commercial Turbojet ... 60
The TJ38 is a simple, low-temperature, low-pressure-ratio turbojet for commercial transports. It represents a redesign of the Olympus engine by Wright Aeronautical in collaboration with Bristol Aero Engines. (Paper No. 45A) — **Leonard Green** and **Bruce Gordon**

The Path to Manned Satellites 64
Manned aircraft will serve as stepping stones to eventual manned satellites and space vehicles. Major problems to be solved relate to aerodynamic heating, stability, and control. (Paper No. S80) — **K. E. Van Every**

New Steel OK Up to 1000 F 68
A new 5% chromium steel — Vascojet 1000 — provides high strength over temperature ranges from −100 F to 1000 F. (Paper No. S67) — **John C. Hamaker, Jr.**

Missile Hydraulic Systems 73
Missile manufacturers want hydraulic systems that are designed and produced fast and still have work-every-time reliability. To meet this challenge a missile maker follows three rules for today's designs and points to problems and some solutions for tomorrow's designs. (Paper No. 48C) — **H. J. Ide**

The Jet Transport of 1975 74
The 1975 Supersonic Jet Transport will fly at 65,000 Ft. The Mach 2+ transport demands: high turbine inlet temperatures and better jet nozzle design from the engine builder: lift-to-drag ratios of 10 or better in supersonic flight from the airframe manufacturer. (Paper No. 42B) — **G. C. Rapp**

Specs for Some Foreign Cars 77
Foreign Car Specifications listed in five groups according to size classifications. (Paper No. S91) — **G. A. Smith**

To order complete papers on which articles are based, turn to page 6.

Continued on page 2

SAE Journal

Contents • July 1958 • Continued

Why Not Turbine-Powered Missiles? 78

Don't overlook the possibilities of turbine-powered missiles for the future. Advances in turbine engines could make possible air-breathing Mach 4 missile systems having marked operational and economic advantages. (Paper No. 48A) — **R. E. Neitzel** and **M. A. Zipkin**

New Aid for Icing Studies 80

Icing studies lead to evaluating accuracy of rotating cylinder method of measuring water content in air stream. Useful range of method determined. — **C. H. Fish** and **J. B. Werner.**

Energy Sources for MAP Systems 82

For missile auxiliary power systems in the capacities usually required, the lightest power source for durations up to one or two minutes is a flywheel driving a variable-displacement pump which supplies the control system and an alternator for electrical power. (Paper No. 48D) — **E. I. Brown** and **R. W. McJones**

Optimum Mileage for a Jet 84

Optimum Mileage for a Jet usually results from a specific cruise-climb flight path. This is the conclusion drawn from experience with military jet transports. Paper No. 38B) — **W. M. Stout** and **R. E. Sliney, Jr.**

Rockets for That Trip to the Moon .. 85

For a Trip to the Moon nuclear rockets could be used out in space, but chemically fueled rockets would be needed for the first stage of the flight from earth. — **Dr. C. R. Lewis**

Heat Limits Hypersonic Flight 86

Hypersonic flight through the atmosphere brings massive heating problems, but aerodynamic design can minimize leading edge heating. (Paper No. 39A) — **W. F. Radcliffe**

Hydrogen as a Flight Fuel 88

Basis for renewed interest in hydrogen as a source of energy for flight propulsion is a recently developed technique for reliable, continuous production of liquid hydrogen in a form suffering only small evaporation losses in storage. — **Hugh Harvey**

1958 Truck Trends 89

The many significant truck engineering advances announced during the past 12 to 18 months reflect the tremendous amount of engineering activity now going on in the truck industry.

2-Stroke Engine Makes Strides 105

Designing for chain-saw application leads to weight and cost reduction. Powering of target aircraft hints at widening use. (Paper No. S62) — **W. B. Burkett**

Transmission-Differential Combine .. 106

A differential fixed with respect to the body affords one possible solution to lower cars within the near future. Were this line of design attack pursued, combining the transmission and the differential would be indicated as a means of developing a suitable rear-suspension and rear-axle arrangement. (Paper No. S93) — **Philip O. Johnson**

Briefs of SAE Papers 5
Ways Sought to Cut Throttle Deposits (Paper No. S69) 117
Simplicity Features Ground Speed Indicator (Paper No. 40A) 117
How Five Companies Organized for Automation (SP-322) 118
Nuclear Submarines Feature the Shippingport Type of Powerplant 118
Safe Pilot Ejection Level Drops to 500 Ft (Paper No. S86) 119
How Heat Flows from Solid Exhaust Valves (Paper No. S88) 120
Higher Power Outputs Accentuate Wear Problems (Paper No. S103) 120
Cost Control Needs Supervisor-Employee Aid (SP-322) 120
New Truck Chassis Meets Challenge for More "Cube" 121
Solar Battery Heralds Sun-Power Age 122
Gasoline, F-P Engines, Gas Turbine Compared 122
Unitized Design Adapted to Low Cars (Paper No. S92) 122
Outboard Motor Builders Face Many Tough Problems (Paper No. S101) 122
Turbines Are Tops for Small Boat Power (Paper No. S87) 124
4 Ways to Reduce Casting Tolerances (SP-322) 126

The SAE Story for July

CEP News 107
About SAE Members 110
Rambling Through the Sections 114
SAE National Meetings Schedule 115
News of SAE 116
Announcement of the 1958 SAE National West Coast Meeting ... 116
New Members Qualified 145
Applications Received 150

More on page 1

To order complete papers on which articles are based, turn to page 6.

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Performance Evaluation of Shrouded Rotor in Flow Normal to Its Axis, R. S. ROSS, R. S. JOHNSON, Jr. Paper No. 37A. Presented Apr. 1958, 9 p. Program conducted at Goodyear Aircraft Corp. on shrouded rotor of large buried type; rotor is entirely enclosed in form of ducting which will permit hovering conditions as well as forward flight conditions; features of wind tunnel model; internal duct evaluations and force measurements; study shows that concept is feasible and yields reasonable performance with good growth capabilities.

Progress Report on Helicopter Maintenance and Serviceability, T. R. PIERPOINT, R. S. LESLIE. Paper No. 37C. Presented Apr. 1958, 13 p. Summary of progress made from 1955 until present; design factors; training of personnel; spare parts selection and distribution; instrumental literature; organization of maintenance facility; selection, design, and application of service tools.

Commercial Jet Transport Piloting Techniques, D. P. GERMERAAD. Paper No. 38A. Presented Apr. 1958, 23 p. Following aspects covered: starting, taxi, and runup procedures; emergency procedures for takeoff; precision cruise control and fuel management; flying in jet streams, clear air turbulence, and frontal weather; in-flight trouble analysis and control; holding and alternate airport procedures; smoke evacuation; rapid descents; and ditching.

Solid and Liquid Rockets, G. S. SUTHERLAND. Paper No. 42A. Presented Apr. 1958, 17 p. Paper, confined to conventional chemical rockets, compares characteristics of large solid and liquid rockets with reference to performance dealing with specific impulse and propellant loading fraction; reliability; logistics, i.e. handling, transporting, launching; and costs; areas of application.

Powerplants for Supersonic Transports, G. C. RAPP. Paper No. 42B. Presented Apr. 1958, 18 p. Introduction of supersonic transport into airline operation predicted for 1970–75; problem areas facing engine designer and systems characteristics having effect on propulsion system requirements; integration of airframe requirements with basic engine capability; characteristics of supersonic transport established in terms of suitability of engine capability with altitude requirements, desirable engine characteristics, and aircraft productivity.

Naval Developments in Carrier Navigation and Traffic Control, A. B. WINICK, J. L. LOEB. Paper No. 43A. Presented Apr. 1958, 7 p. TACAN (Tactical Air Navigation system), developed by Navy, covers three phases of carrier navigation and control, namely, traffic control, wave off and transition, and precision landing phase; in first two phases, air-derived information via air-to-ground data link message is received; in third phase ship-derived data is obtained from precision radar and commands are transmitted by ground to air data link.

Planned Missile Producibility, W. PRINCE. Paper No. 44B. Presented Apr. 1958, 4 p. Approach taken by Martin Co. in setup for missile mass production; to facilitate manufacturing, shipping and field assembly, missile is analyzed and subdivided into major sections such as wing, stabilizer, and fin assembly, nose, center, and aft sections; fabrication is divided into structural and electronic manufacturing; packaging and handling of components; cost studies.

Use of Adhesives in Aircraft Industry, W. K. BAILEY. Paper No. 34B. Presented Mar.–Apr. 1958, 12 p. Use of adhesives on B-58 at Convair; advantages of bonded structure; where and how it is used; all of bonded structure considered as falling into following two general types; beaded panels

Continued on page 6

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14	126	140	155	172	185
15	127	141	157	173	186
16	129	142	158	174	Inside front cover
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Briefs of SAE PAPERS

Continued from page 5

used in fuselage area, and sandwich panels; problems associated with use of adhesives.

Practical Aspects of Boundary Layer Control, H. C. HIGGINS. Paper No. 37B. Presented Apr. 1958, 7 p. Data available on effectiveness of certain kinds of boundary layer control (BLC) for producing lift make it possible to conduct parametric analysis of aircraft, utilizing BLC; investigation limited to blowing systems; it is concluded that engine bleed air BLC will not be used on efficient subsonic jet airplanes; BLC systems of type considered will provide takeoff performance improvement.

Military Jet Transport Piloting Techniques, W. M. STOUT, R. E. SLINEY, Jr. Paper No. 38B. Presented Apr. 1958, 19 p. Basic differences in philosophies behind commercial and military operation; fact that military crew is not limited to fixed number of working hours is advantage in mission planning; preflight preparation; mission planning; ground operation; takeoff; climb out; enroute climb; presentation of cruise data; maximum endurance and descent data; approach and landing; miscellaneous charts.

Aero-Thermodynamic Aspects of High Speed Flight, W. F. RADCLIFFE. Paper No. 39A. Presented Apr. 1958, 9 p. Aerothermodynamic effects investigated with particular reference to heat transfer relations; glide and ballistic vehicles and their design limitations, considered.

Physiologic Effects of High Speed, High Altitude Flight, J. W. RAEKE. Paper No. 39B. Presented Apr. 1958, 10 p. Decrease in atmospheric pressure with increasing altitude presents most serious problem oxygen and pressure requirements; breakoff phenomenon; visual problems; pilot escape and factors limiting ejection escape at high speed; investigating weightlessness and danger of exposure to cosmic radiation.

Simplest Doppler Ground Speed Indicator, J. R. IVERSON. Paper No. 40A. Presented Apr. 1958, 14 p. Basically, all ground velocity indicators and navigation systems for propeller driven and jet aircraft, helicopters, airships, and some missile types, developed by Ryan Co., involve radar receiver transmitter, Doppler frequency measuring unit, and method of stabilizing Doppler data against aircraft attitude; features, characteristics and operation of Ryan Model 114; flight test results.

Integration of Navigational Flight Information for Jet Interceptor Aircraft, M. V. FIORE. Paper No. 40B. Presented Apr. 1958, 8 p. To navigate efficiently, pilot needs continuously following data: present location of aircraft; bearing to target; point of return information; possible alternate destination; efforts made to integrate instrument display; use of E6-B dead reckoning computer; requirements in designing instrument panel include interacting functions of human operator in weapon system.

Integrated Instruments for Jet Transport, G. W. HOOVER. Paper No. 40C. Presented Apr. 1958, 9 p. Fundamental information requirements stated for separate phases of flight, such as takeoff, normal flight, navigation, mission, return, traffic control and landing; description of system, developed under Army-Navy Instrumentation Program; one of building blocks of generalized system is that of sensors, or data gathering elements.

Possibilities and Problems of Some High Energy Fuels for Aircraft, W. T. OLSON. Paper No. 41B. Presented Apr. 1958, 34 p. Factors leading to jet engine fuel selection, chemical possibilities for high energy fuels, and problems attendant to their application to flight propulsion; problems with magnesium and aluminum; boron compounds; current effort centers around obtaining liquid fuel with heat of combustion of order of 40% more than hydrocarbons; it probably will be compound of boron, carbon, and hydrogen.

Application of Flexible Production System to Quantity Manufacture of Guided Missiles and Rockets, J. P. ROGAN. Paper No. 44A. Presented Apr. 1958, 5 p. Approach taken by Douglas Aircraft is based on following

Continued on page 131

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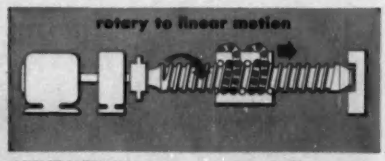

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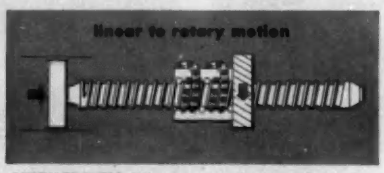

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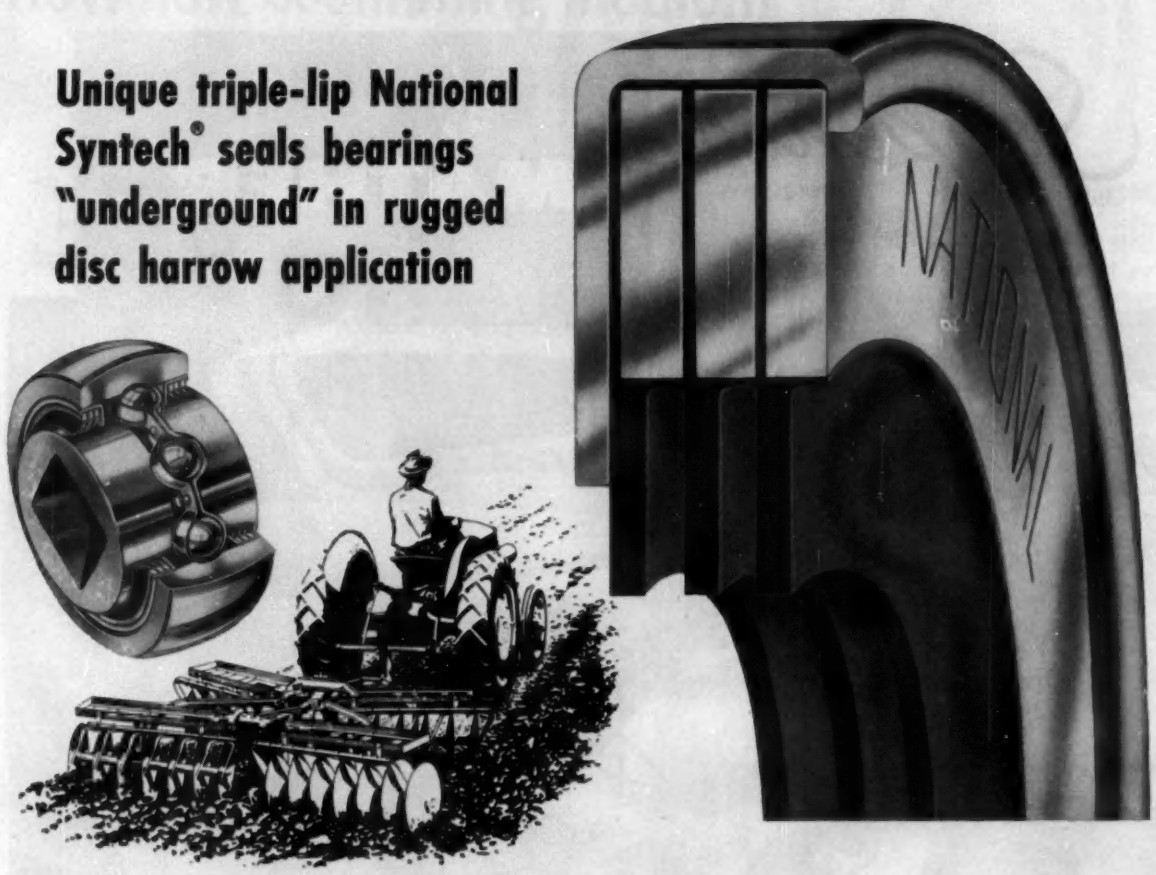

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The seal is rugged and extremely simple in design. It consists of three identical synthetic rubber sealing members bonded to metal washers and enclosed in a rigid steel outer case. Use of the "straight" Syntech sections keeps torque low, simplifies flush lubrication, and permits the seal to accept a high degree of runout and misalignment where needed.

For complete information, call your National Applications Engineer or write direct

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
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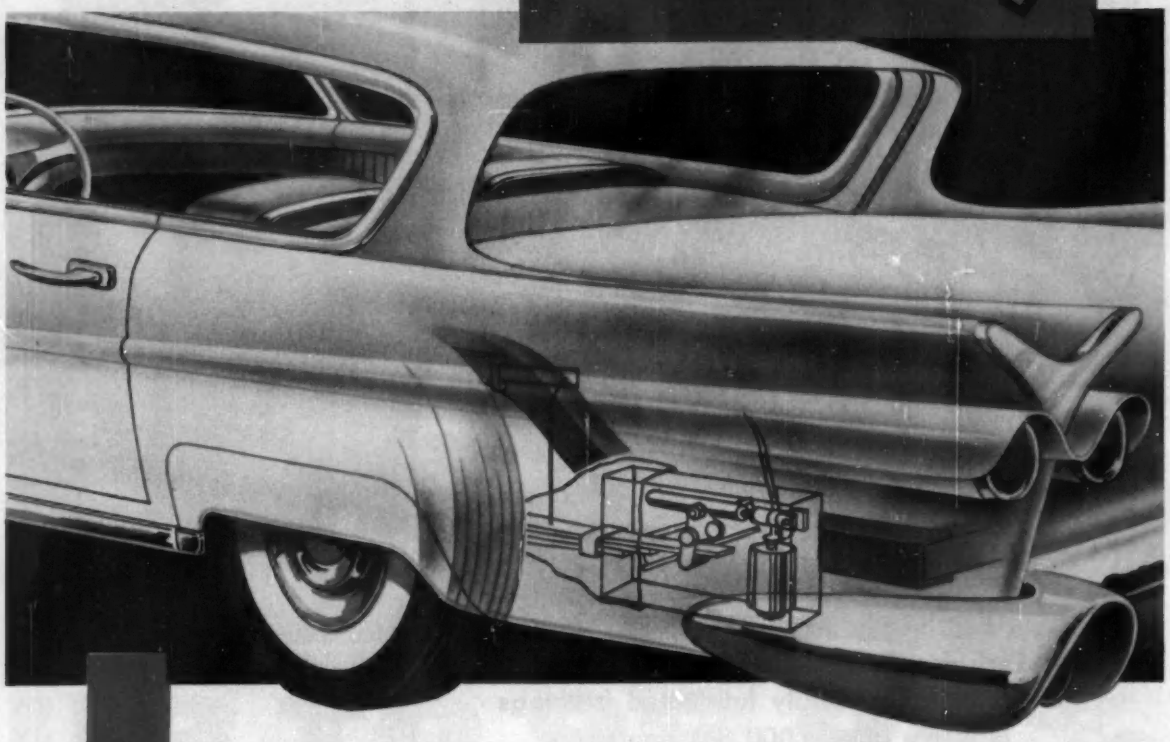
4840

the "LOW DOWN" on

Suspension by MATHER



The drawing above illustrates a prototype of an automatic leveling suspension design for passenger cars, station wagons, and light trucks.

The design utilizes a high degree of lateral stability inherent in leaf spring suspensions.

This suspension-leveling system adjusts the ride to varying load conditions *and at a lower cost than any other now in use.*

Write or call The Mather Spring Company for complete information on this mechanical design or details on any suspension system you may require.

MATHER

THE MATHER SPRING COMPANY • TOLEDO, OHIO

How new cushioning medium makes dream seats practical—

creates new R-O-O-M, new comfort, new appeal!

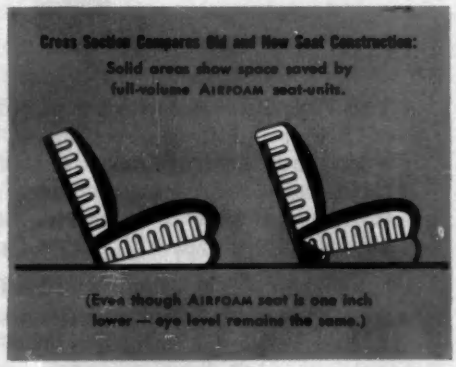
LIMITED INTERIOR SPACE needn't limit creative thinking about seating. Not if you utilize the wonderful new *freedom of design* offered by full-depth AIRFOAM.

For full-depth AIRFOAM, molded to your specifications, is an astoundingly versatile cushioning *medium* that eliminates bulky components.

It allows you to do things above and beyond the limitations of old-time cushionings. They're new things—inspiring things—sales-minded things – and because of the unique advantages of AIRFOAM, forever *practical!*

Some of the best names in the industry have benefited greatly by consulting AIRFOAM Development Engineers. May we answer some key questions for you? Goodyear, Engineered Products Dept., Akron 16, Ohio.

How are headrest, back and arm cushioning joined?
AIRFOAM can make them a single, wrap-around unit.
Isn't piping expensive?
NOT WITH AIRFOAM. Molded all-one-piece, it means fewer operations.
I don't like hard edges!
THESE ARE SOFT. Molded in AIRFOAM, they hold their shapes for car life.
Can this bolster hold its shape?
FOR CAR'S LIFE! It's permanently molded AIRFOAM.
Where does the swivel-base mechanism go?
WHERE IT BELONGS. Molded AIRFOAM seat cushions take far less depth than conventional springs and padding.


Cross Section Compares Old and New Seat Construction:
Solid areas show space saved by full-volume AIRFOAM seat-units.
(Even though AIRFOAM seat is one inch lower — eye level remains the same.)

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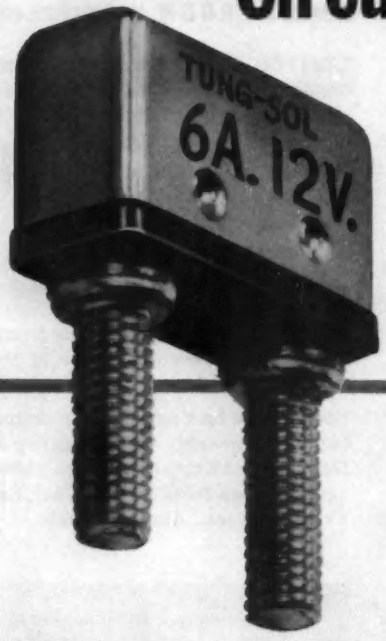
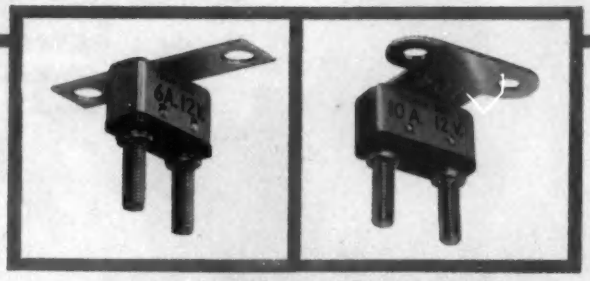
Airfoam—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Tung-Sol 12-Volt Remote-Reset Circuit Breakers



Positive "Lock Open" Action gives complete protection against:

BURNED-OUT ACCESSORY MOTORS AND WIRING
PERMANENT BREAKER DAMAGE
RUN-DOWN BATTERIES



Standard Mounting Brackets

The Tung-Sol remote-reset type circuit breakers *lock open*, instead of continuing to pulsate, when the circuit is overloaded or shorted. When the cause of the overload or short is removed, the breaker is then remotely reset. It reactivates the circuit within 30 seconds.

Available in 6, 10, 15, 20, 30 and 40 amp. ratings, in a choice of two mounting brackets, Tung-Sol Remote-Reset Circuit Breakers are used in a wide variety of automotive applications. For further information write Engineering Department.

METHOD OF OPERATION

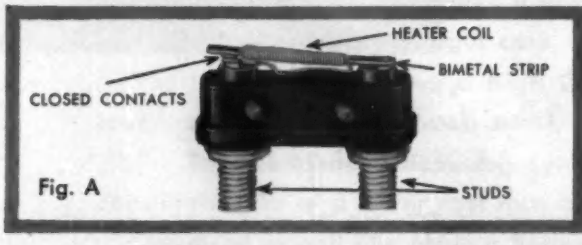


Fig. A

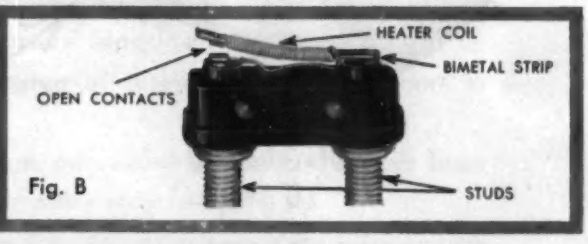


Fig. B

NORMAL CONDITIONS

When circuit conditions are normal, the current flows thru the strip which is attached across breaker studs. When contacts are closed, the heater coil is short circuited and has no heating effect. (Fig. A).

EMERGENCY CONDITIONS

When a short circuit or overload occurs, the increased current causes strip to bend away from contacts. (Fig. B). When the contacts part, the coil is automatically inserted in the circuit.

ELECTROSWITCH DIVISION (ts) TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

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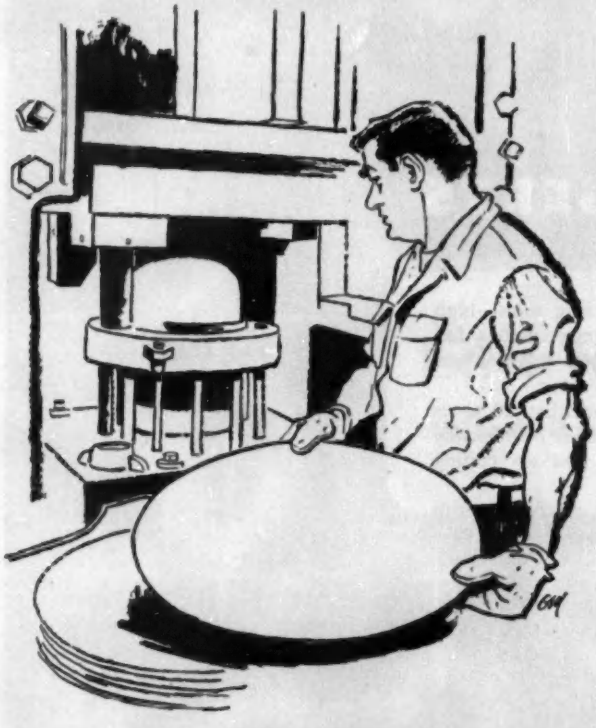

Longer life and/or lighter weight come naturally when you use N-A-X HIGH-STRENGTH steels. One of these two steels may fit the specifications of your product:

N-A-X FINEGRAIN STEEL
N-A-X HIGH-TENSILE STEEL

Both are low-alloy, high-strength steels with many diversified applications in modern metals design. Compared with mild-carbon steels—

- **They are 50% stronger**
- **They have high fatigue life with great toughness**
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- **They are readily welded by any process**
- **They offer greater paint adhesion**
- **They are stable against aging**
- **They can be cold formed readily into difficult stampings**
- **They polish to a high luster at minimum cost**

N-A-X FINEGRAIN'S resistance to normal atmospheric corrosion is twice that of structural carbon steel. Where greater resistance to extreme atmospheric corrosion is important, N-A-X HIGH-TENSILE is recommended.

Let us show you how you can use N-A-X HIGH-STRENGTH steels to make your product last longer and/or weigh less.

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N-A-X Alloy Sales Division, Dept. F-8

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And Carmet Indexable inserts are available in more than 20 styles and sizes and in six different carbide grades—each insert permanently marked for positive grade identification—to give you *top* cutting performance.

Carmet tool holders and Indexable inserts make machining with carbides practical for any size plant. Match a Carmet tool to your requirements—or let Carmet give you engineering assistance in setting up a complete tooling program—and watch your production climb as costs go down. Inquire today.

• *Allegheny Ludlum Steel Corporation, Carmet Division, Detroit 20, Mich.*

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CARMET TOOL HOLDERS and INDEXABLE INSERTS

Expanded to 16 pages, this latest edition contains specifications of Carmet tool holders and Indexable inserts, replacement parts for tool holders, and information on choosing the proper carbide grade for the job.

ADDRESS DEPT. SA-7

MATCH THE TOOL TO THE JOB

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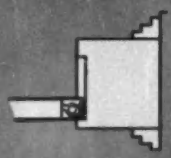
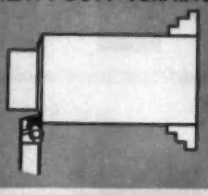
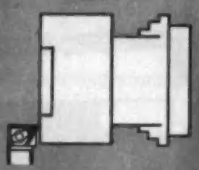


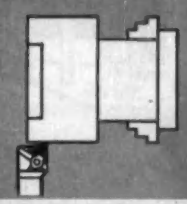
STYLE **SBTR** HEAVY-DUTY TURNING



STYLE **TFTR** FACING



STYLE **TGTR** FACING



STYLE **SFTR** FACING

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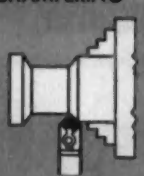

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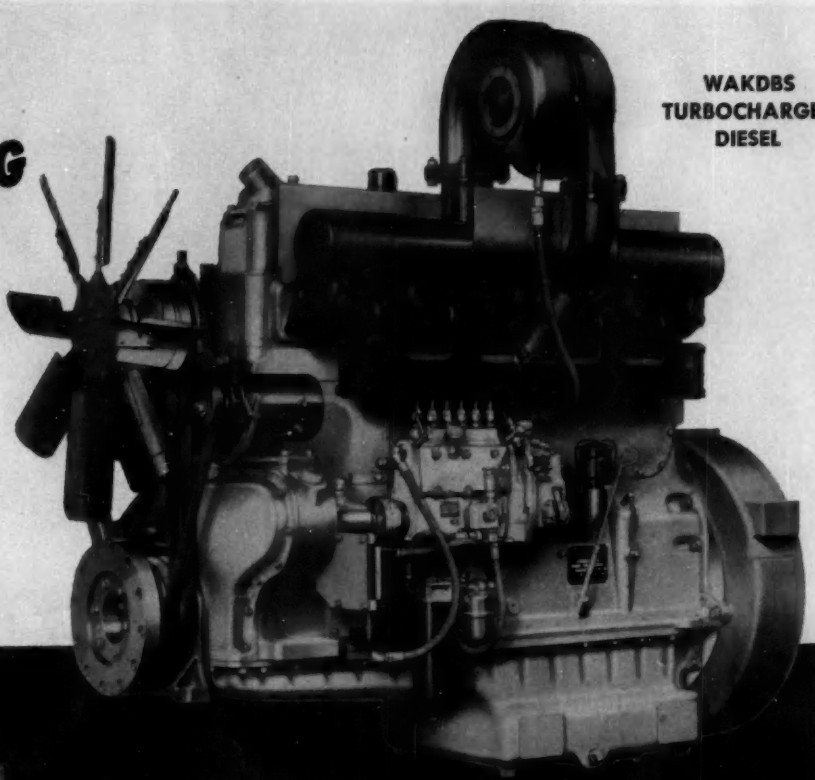

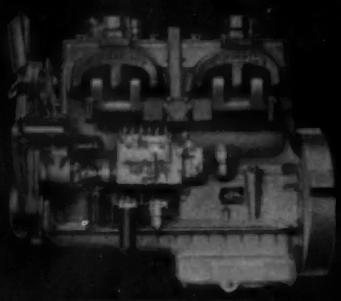

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LOOK INSIDE

the Sherman Pin Setter and you will find those smooth-operating, trouble-free

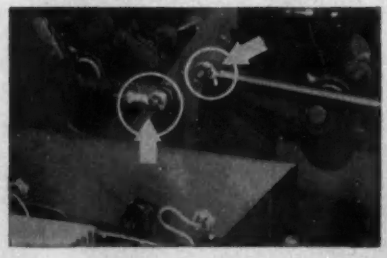
HEIM *Unibal*® ROD ENDS

Bowlers like duckpins at all hours of the day — times when pinboys are not always available. The Sherman Pin Spotter is an automatic device for setting the pins on their spots, sweeping the alley clear of deadwood, replacing remaining pins for next shot, and returning balls for next frame. These pin setters, presently made by Crompton & Knowles Corp., must be ready to operate at all times at the push of a button.

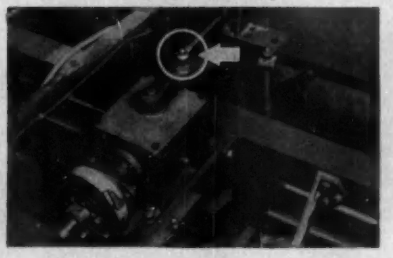
Photos taken at Johnson's Bowling Academy, Hamden, Conn.

HEIM UNIBAL ROD ENDS contribute trouble-free dependability to the push-pull rods on the distributor table drive assembly, and carry the full thrust load of the sweep drive assembly (the swinging arm which sweeps the alley clear of deadwood).

Distributor table drive assembly.



Sweep drive assembly.

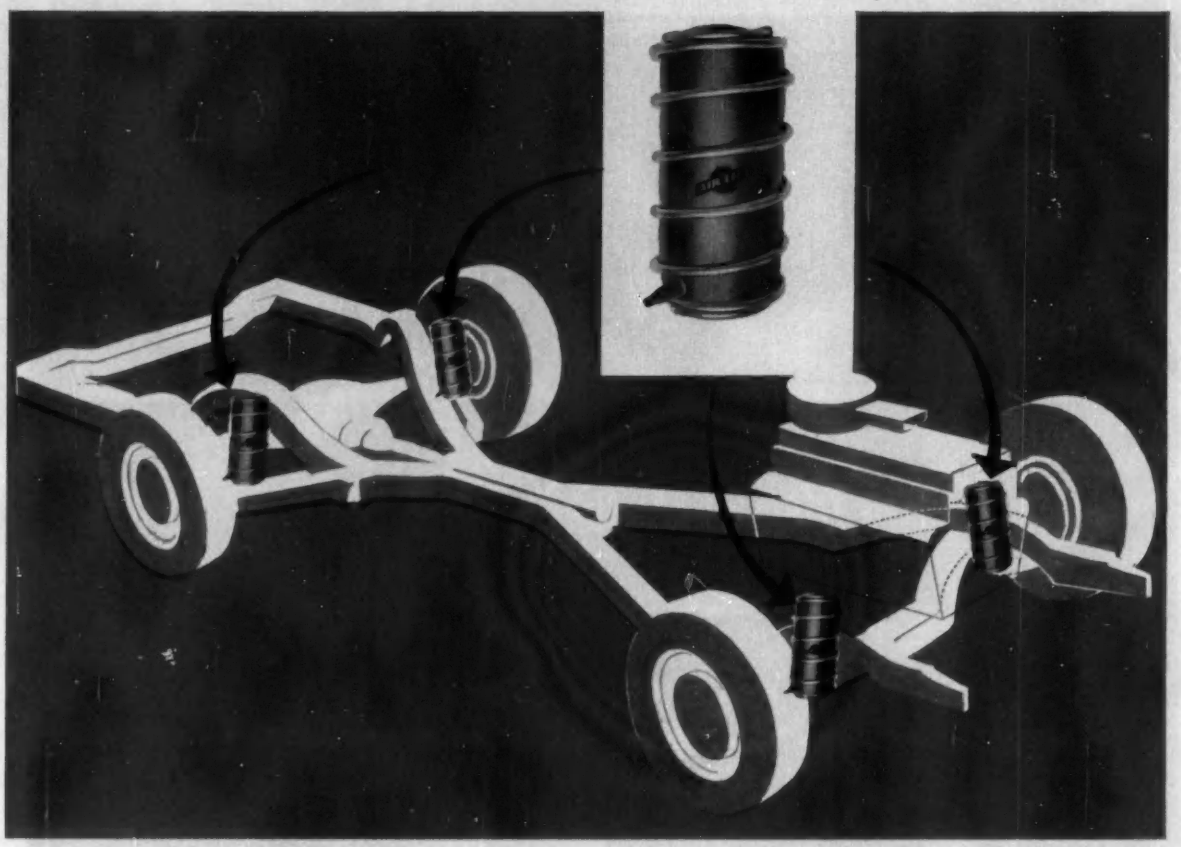


If you could look inside any equipment where power/motion is being transmitted at varying angles, you would find the Heim Unibal being used in more and more applications. It is the original Spherical Bearing developed, engineered, and manufactured by The Heim Company for over fifteen years.

Load ratings, specifications, and sizes are all shown in the complete catalog of Heim bearings. Write for copy, and for any special engineering data.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT



Pneumatic Spring Controls are made with Enjay Butyl to provide quieter, softer cushioning in automobiles.

ENJAY BUTYL

actually lets you ride on air!

Enjay Butyl Rubber is used by the Armstrong Rubber Company, West Haven, Connecticut, in the production of Air Lift Pneumatic Spring Controls for the Air Lift Company, Lansing, Michigan. Butyl Air Lift units are inserted between leaf spring and frame to support overloads and cushion all moving parts of suspension. Inflatable to meet load requirements, these units protect vehicles–provide a smoother, safer ride.

Each week the Armstrong Rubber Company turns out thousands of Air Lift units made from Enjay Butyl Rubber. They chose Enjay Butyl because of its superior air retention and resistance to aging. Since tough, weatherproof Butyl is low in cost, it may be the answer to lower production costs for you. For complete information and expert technical assistance, call or write the Enjay Company.

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Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

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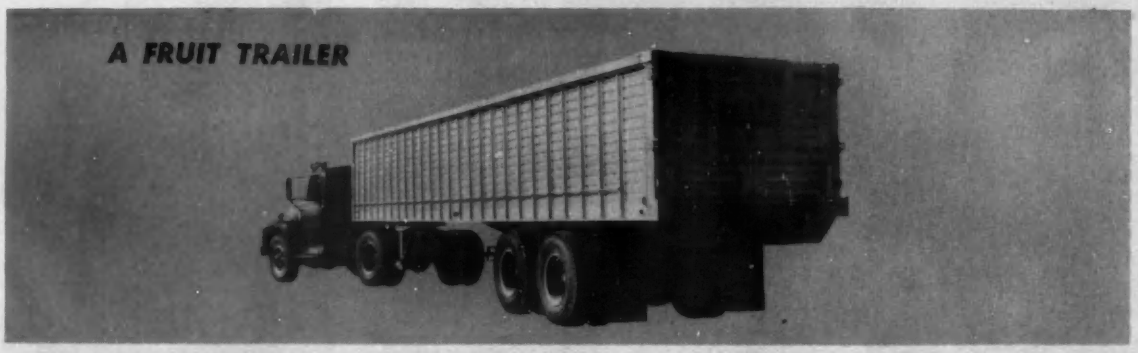

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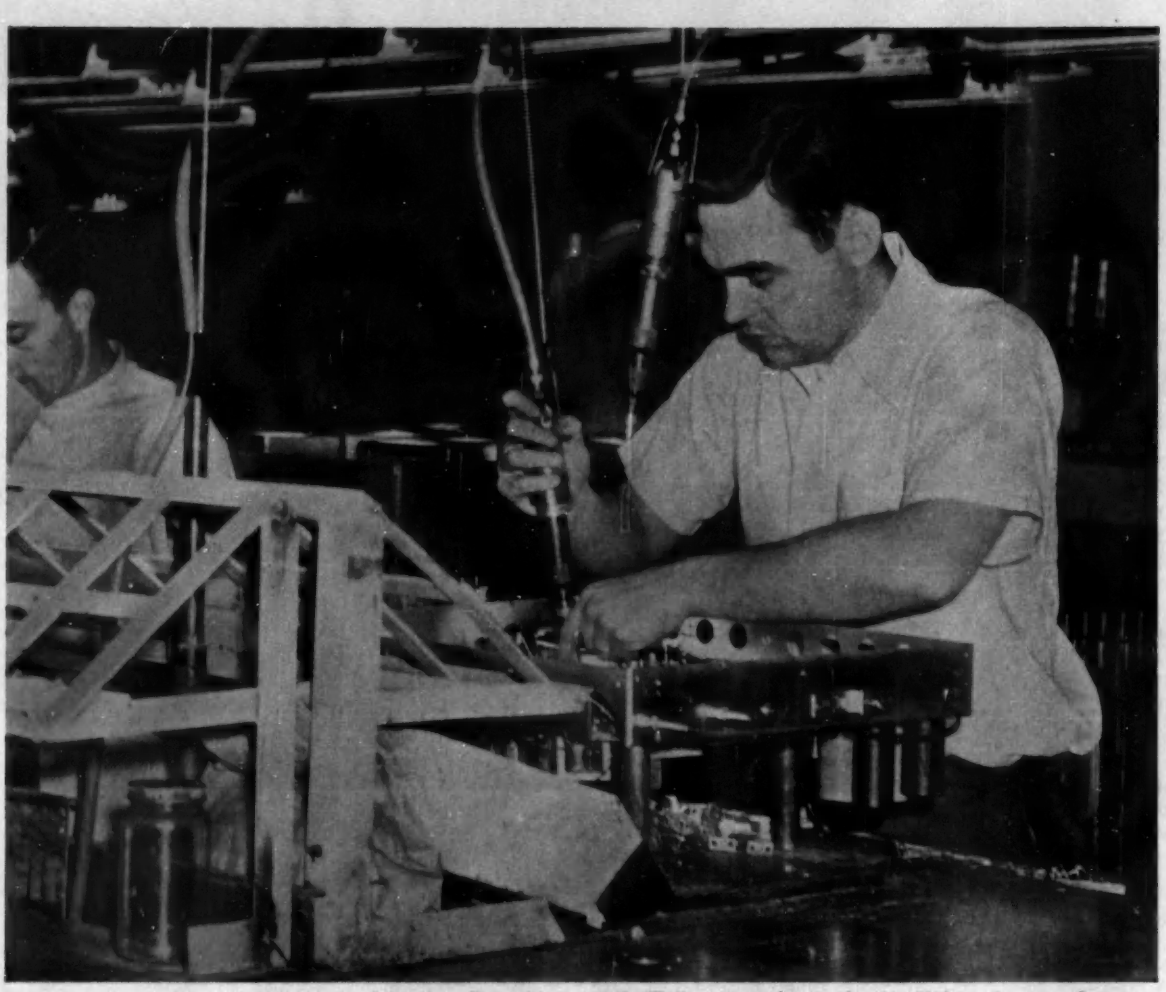

Gardner-Denver's versatile Keller air tools speed color T.V production. Operator uses one to run flat nuts... the other is at his finger tips to tighten hex-head screws.

Gardner-Denver air tools help speed low-cost color TV

The high cost of producing color TV sets is on the run —good news for production men and consumers alike. Among the reasons are improved manufacturing methods and increased use of highly efficient equipment —such as fast, accurate Gardner-Denver screw drivers and nut setters.

Made of standardized components, these air tools pay off in a hurry. For example, you step up efficiency of many work stations by using two or more tools, with bits and finders to fit a variety of fastenings.

Incorporating the new No. 2 air motor, these air tools have increased speed-torque range, increased power, low noise level and low maintenance. A number of clutches are available, including the new "Safe-Torque"* clutch for precise torque control from 10 to 108 inch-pounds.

Take advantage of the many cost-cutting advantages of Gardner-Denver's Keller air tool line. Ask your Gardner-Denver representative for details, or write for Bulletins 12-101 and 16-301.

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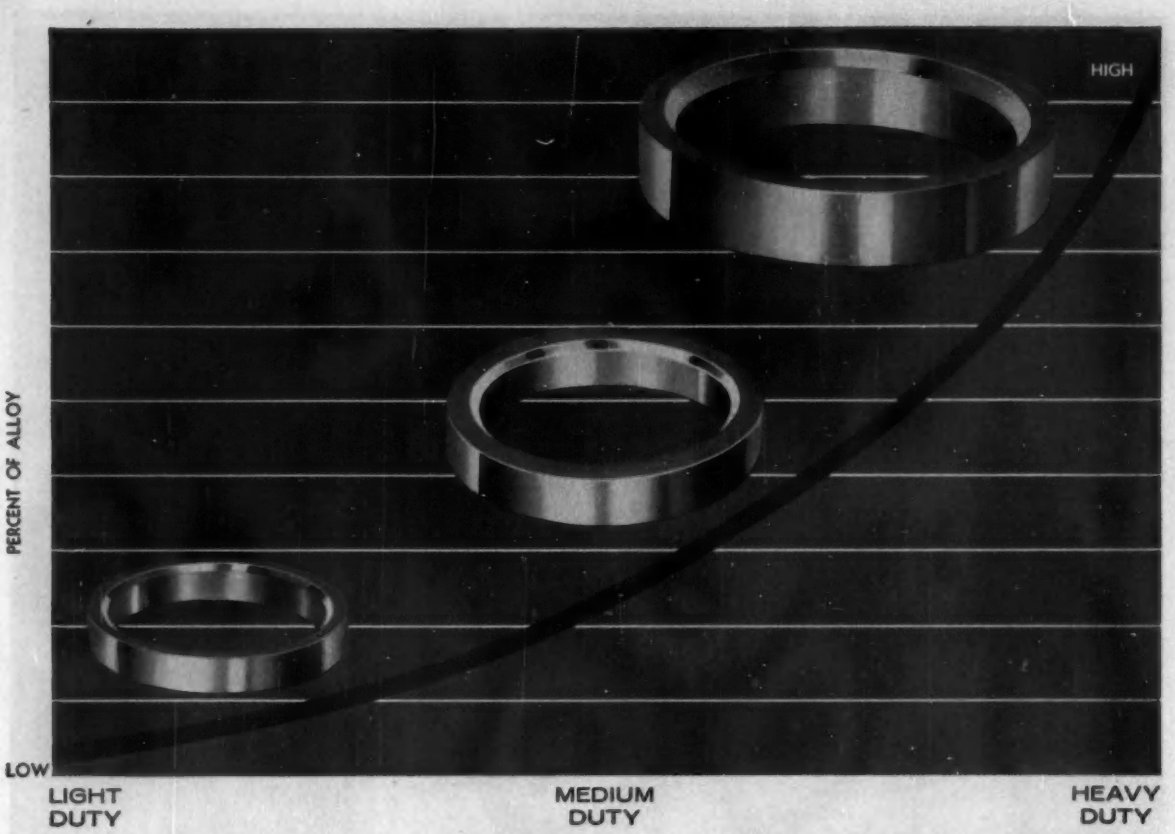

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SAE Journal is available on microfilm from University Microfilms, Ann Arbor, Mich.

A complete index of all technical articles appearing in SAE Journal from January through December will appear in the December issue.

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For The Sake of Argument

Participation is More Fun . . .

By Norman G. Shidle

"PARTICIPATION" and "representation" are too often thought of as synonyms. Try to organize or reorganize a department or a committee, a company or a society and watch how frequently this error confuses discussion.

"Representation" without "participation" is possible; but not the reverse. Participation *is* representation . . . representation with an impact. It always means: "Get in there and pitch."

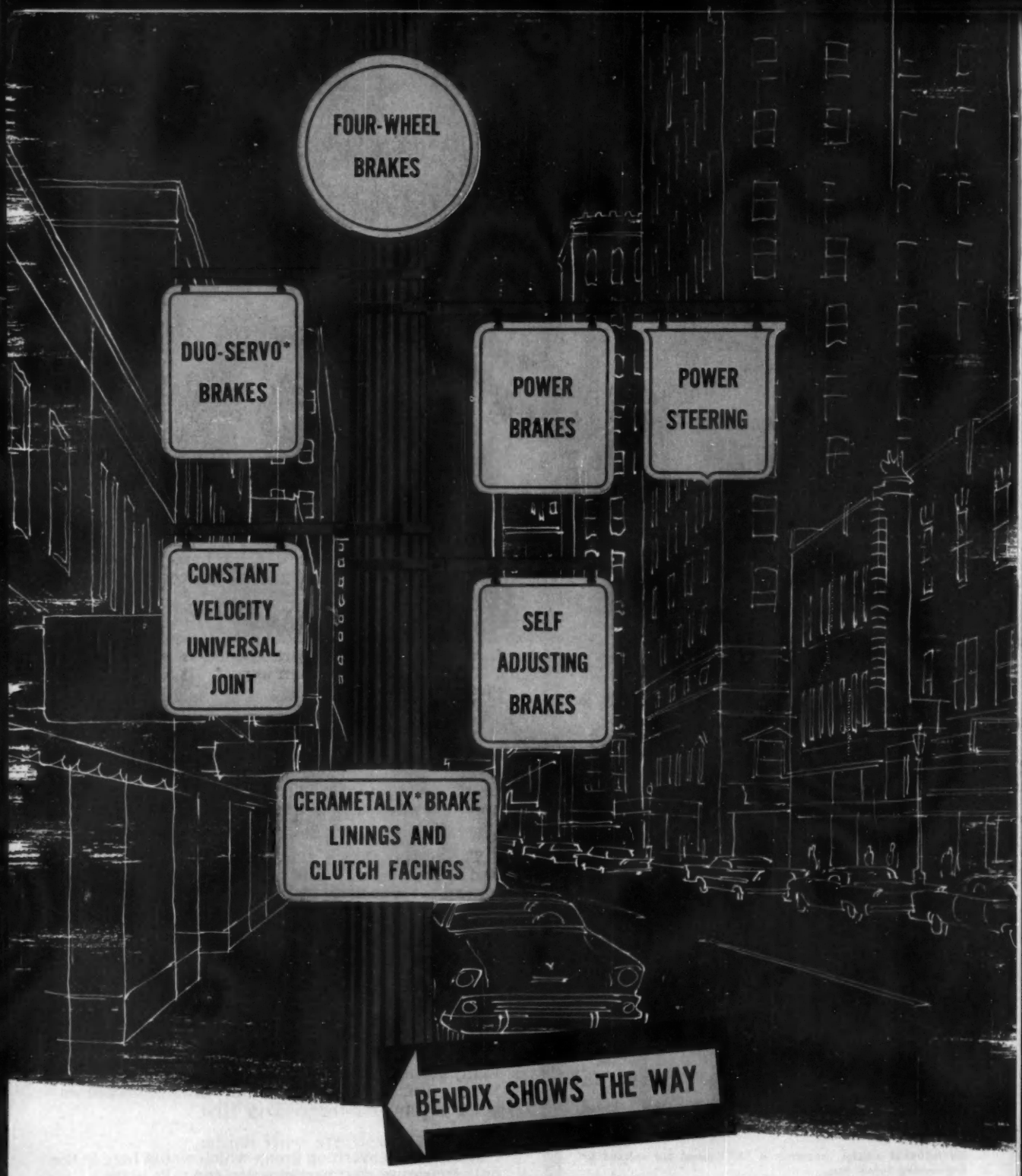
Representation is something a stronger power gives to a weaker one. Once conferred, it makes possible, but doesn't demand further effort from recipients. But participation *requires* constant activity by the participator . . . whether tied to representation or not.

The relationship is akin to that between authority and responsibility . . . and the knowledge that "authority can never be delegated; it must be earned."

Besides, participation is lots more fun. It's always more fun to grasp an opportunity than to exercise a right.

Representation can be a way to limit — as well as to encourage participation, too. People who show up best on an organization chart sometimes end up with least to say about what goes on. (Ask anybody who has ever been a member of a board of directors composed entirely of employees.)

A boss or a governing group which wants help is the only guarantee that participation can take place.



Each of these key Bendix developments has had an important influence on the course of automotive design. New Bendix developments now in process demonstrate continuing foresight into the needs of the automotive industry. Let us consult with you now on problems relating to your future.

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from SAE meetings, members, and committees

TRIPS around Mars or Venus would require an average of about 1,000,000 miles of travel every day for three years, counting the necessary spiraling around in the solar system.

REPORTING on an epidemic of piston top-land and top-ring breakage, an engine manufacturer was asked how many failures occurred. "Two in the same distributor's territory," was the reply.

IRBM NOSE CONE decelerates upon reentry into the earth's atmosphere as severely as would a passenger car if it could slow from 60 mph to a dead stop in 2 ft. The nose cone has to be designed to withstand this terrific loading, as well as the attendant fierce heat.

That's why to destroy it in mid flight an anti-missile missile is probably going to have to come very close with a mighty big bang. Then if successful — and if a high-altitude nuclear explosion is caused — there may be a problem with dangerous fall-out over a large area.

IT PAYS OFF to test a mechanical prototype vehicle before the usual true prototype is built, according to experience relayed by Ford engineers. This procedure, used in development of the new-type Thunderbird, made possible changes in the final design well before it was necessary to release the body structure for tooling and before construction of the true prototype.

With structural durability a prime development consideration for the new 4-passenger body, the mechanical prototype was tested for 1500 miles on a course so rough that shock-absorbers had to be changed every 120 miles to maintain even minimum effectiveness.

Indicative of the sort of changes made after mechanical prototype testing and before true prototype building were these:

- The front spring pocket and outer metal gage were increased and arc welding was specified in this area.
- A 1/3-in. thick plate was added to the under side of the arm bracket.
- The inner and outer portion of the track-bar brackets were designed with flanges for added rigidity.
- A tie plate was added from the inner side-rail face to the upper suspension-arm bracket . . . and the entire periphery of the spring pocket lower flange was welded to the side rails.

THE uncertainty in the location of Europe relative to America is now of the order of a thousand feet . . . which has significance for intercontinental missile folks.

ONE MAN LESS at a missile launch site may eliminate need for something like 75 men along the line of supply. That's why operational simplicity of the "bird" and its ground support equipment — even if achieved at the expense of considerable manufacturing and maintenance complexity — is of great interest.

SO MANY MEN ARE COLOR-BLIND, a truck engineer tells SAE Journal editors, that it's a good idea to stick to black and white charts.

"We have difficulty here in our engineering department for that reason," he reports. "The result is a loss in man-hours . . . and two men have to study a chart instead of one."

ONLY ABOUT 15% of a modern motor fuel is as nature formed it. The remaining 85% has been chemically altered.

EIGHT YEARS have passed since engineers started on the job of giving this country nuclear aircraft propulsion, although maybe it doesn't seem that long. Despite the discouragements, spokesmen now say there's ample engineering evidence that nuclear propulsion for certain types of aircraft is inevitable. They advise: Follow the example of the Wright Brothers. When the Wright Brothers first tried to fly, they were satisfied just to get off the ground. Let today's engineers get a nuclear-powered plane into the air first. Don't insist at the outset that it must power a weapon system to beat every other comparable weapon system, regardless of the experience behind its powerplant.

HYDROSTATIC PRESSURE fatigue of the fuselage of a Lockheed C-130A cargo airplane has served to point out weak spots in the structure, D. S. Morcock writes. This makes the tests worth while, even though they don't include the effect of propeller blast and vibration and they do use only a single load to stimulate fatigue effects of all loads met in flight.

Testing is accomplished by filling the fuselage with water under pressure and at the same time surrounding the fuselage with water to eliminate differential pressures due to water head.

Water is used for pressurization because there's less damage in case of a blowout than when air is used. Also, water can be cycled faster because only a small volume need be moved to pressurize the fuselage. Testing is being carried out at the Georgia Division of Lockheed, where the C-130A Hercules is built.

No Recession in Technical

. . . at SAE Summer Meeting

THERE was no recession in the depth and breadth of technical talk at the 22 sessions of SAE's 1958 Summer Meeting in Atlantic City. Headquartered again at Chalfonte-Haddon Hall, more than 60 technical papers were presented — and many authors faced spirited discussion.

As usual, those in attendance took away personal professional values greatly in excess of those provided by the information gleaned at formal sessions. Particularly fruitful were the afternoon round tables, where attendance confined itself to those mutually and deeply interested in a given topic. Not only did these small groups provide a chance for relaxed person-to-person interplay, but they gave an unusual chance for development of new intimacies and new friendships at the technical level.

Helpful in these same respects was the "Early Bird Breakfast" at which SAE Vice-President J. E. Adams and his Production Activity Committee were sponsors. Centered on the topic, "The Early Production Bird Gets the Low Cost Worm," this informal exchange of ideas and data was noteworthy.

Outstanding also was a session on current user-designer problems of those concerned with small engines for trailer refrigeration. Chairmanned by SAE Past-Vice President F. K. Glynn, this session featured six short papers and much revealing discussion.

After-hours activities were enjoyed as usual. This year they included golf, tennis, bathing, and other sports for individuals so inclined; and a "Gaslight Gayeties" party on Wednesday evening, at which Section Stunts — including barbershop quartets — were among the features.

Squeeze on Engineers . . .

. . . reflected by technical challenges in vehicle units.

DEMAND for ever-increased performance and comfort in both passenger cars and trucks, coupled with ever-lower car silhouettes has put the squeeze on every kind of vehicle engineer in recent years. Sounds resulting from this squeeze have been heard with increasing clarity at SAE meetings in the last 24 months. . . . and Summer Meeting sessions brought a rising crescendo.

For instance:

That the "Battle to Quiet Cars Grows Hotter" (as recorded in SAE Journal's May issue, p. 32) was reemphasized in the Atlantic City discussions. Elimination of sounds from body and chassis units, it was reported, came about on one recent model after "exhaustive studies of available information on noise suppression in integral body vehicle constructions." To obtain low interior sound levels with such constructions, one engineer added, is "known to present a challenge to engineers and designers."

It's getting harder and harder to keep cooling fan noise in bounds, too. Increased engine power is requiring larger fans and higher tip speeds. More power accessories are getting in the way of the air as it leaves the fan; are causing more complicated air flows. Larger engines are being put into smaller compartments. Styling is dictating small cores and restrictive grill designs. . . . and all of these elements chal-

SAE PRESIDENT W. K. CRESON (second from left) has met with engineering students from 37 different schools since he took office. Shown at a Student Committee Executive Committee meeting are E. P. White, President Creson, F. B. Esty, Student Committee Chairman P. F. Allmendinger, J. H. Dittfach, and R. A. Peterson.

Talk

lenge the engineer to keep noise levels as low as in the past.

Effect on design determinations caused by stylists and the low silhouette was brought out at several sessions. One car model, for instance, tested originally on a 108-in. wheelbase was finally made 113 in. "to allow for a better proportioned silhouette, including a long, low sweeping hood."

Squeeze for lower cost and higher performance is making difficult provision of long life for batteries and other electrical controls, some engineers said. . . . And recent decreases in tire treadwear were mentioned as resulting from the more-performance and greater-comfort demands.

Similar problems were brought out by engineers faced with maintaining or improving design levels for all kinds of springs and spring suspensions for all kinds of motor vehicles.

Should demand reverse itself toward cheaper, smaller cars in the next few years, the intensity of current-type pressures on the engineer would decrease, those commenting agreed. He would be faced with new challenges, however, to get the most out of less.

But the sessions brought also literally hundreds of specific ideas about how to meet these ever-increasing challenges. Test results, new design ideas . . . how the designer, supplier, and user each can play his part . . . the elements were reflected in papers so consistently as to make the gathering a new high in exchange of practical, use-it-today motor vehicle engineering information.

Aluminum Engines Coming . . .

. . . also new diesel code. Noise Probed.

ALUMINUM engine design, both foreign and domestic, points to lighter and more economical cars in the future, discussion at the meeting indicated.

Revealed also during the sessions were probes aimed at reduction of engine noises . . . and the imminence of a revised SAE code for rating diesel engines.

Savings in engine weight resulting from the projected all-aluminum engines, it was said, will permit the size of other car components to be cut. Brakes, frames, suspensions, and tires all can be smaller and lighter. At the same time, car performance can be stepped up because of the resulting low inertia load.

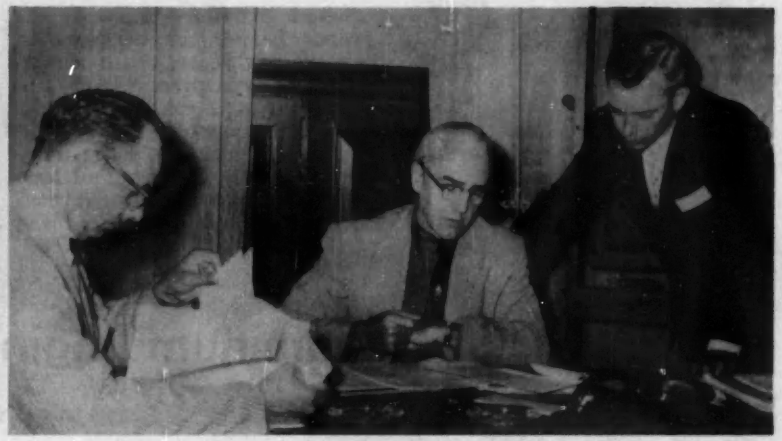
Die castings may replace sheet steel parts in the aluminum-engined vehicles, it was indicated, while aluminum castings can replace heavier cylinder blocks and heads where high strength and rigidity are needed. A rundown on advantages of aluminum for engine parts shows: 2/1 weight saving; 3/1 improvement in thermal conductivity; and a 5/1 stepup in cutting speed in manufacturing. Besides this, parts can be die-cast or permanent-mold casted down to 0.002 in.

Some newer cars have been making noises "like a broom run along a picket fence." And it isn't the knock or ping that comes from low-octane gas in high-compression engines. The noise is a rumble or pounding in the engine. Probes in the combustion chamber show the cause to be multiple ignition points that give faster-than-normal combustion and peak

WORKING FOR PROGRESS — Members of Sections Board Information Committee put finishing touches on plans for Section, Group and Student activities in the revised SAE organization as proposed by the Planning for Progress Committee. Representative of the Sections Committee and of the Student Committee Executive Committees, those pictured are (left to right) Ross A. Peterson; Student Committee Chairman P. F. Allmendinger; William F. Ford; F. B. Esty; George J. Liddell; and Sections Committee Chairman T. R. Thoren.

Ford and Allmendinger are co-chairmen of the Sections Board Information Committee, which also arranged for informed representatives to discuss the Planning for Progress program with Section and Group Governing Boards.

HORNING MEMORIAL AWARD went to Arthur W. Pope, Jr. (left) "for more than 30 years of distinguished active service in the field of mutual adaptation of fuels and engines." Mrs. Harry L. Horning presented the award to Mr. Pope, who delivered the Horning Memorial Lecture on "Single-Cylinder Engine Fuel Research" at a special luncheon. At right is Lloyd Withrow, chairman of the Board of Award.



MEETINGS COMMITTEE CHAIRMAN A. O. WILLEY (center) and S. J. Tompkins (left) are shown reviewing national meetings schedules. Assisting them is William Marble who recently became assistant manager of the Engineering Activity Division of the SAE headquarters staff.

A PYROCERAM NOSE-CONE is examined before the Preview of New Materials session. At left is Robert Sergeson who substituted for V. A. Crosby as session chairman. With him are Blake King, Nuclear Division, Martin Co. and W. W. Shaver (right), Corning Glass Works. (Beginning on page 34 of this issue is an article based on the paper presented by Messrs. Shaver and S. D. Stookey.)

Summer Meeting

. . . continued

pressures 300 psi higher than they should be.

Combustion chamber deposits and high compression engines team up to cause the noise. The deposits get hot enough to start multiple ignition after the spark plug fires. And they build up during city-type driving. When you step on the gas, the deposits glow and the rumble starts. Running at wide-open throttle burns off the rumble-causing deposits — or gasoline additives such as tricresyl phosphate suppress rumble in all but very high (11/1) compression engines.

In the diesel area, it was stated at the meeting, compressing intake air by squeezing it with exhaust gases is a trick accomplished by a new supercharger. The supercharger works because high pressure exhaust gases can push intake air through a tube by compression waves. These waves travel faster than the mixing zone of the two gases. The air thus compressed is fed to the engine until the exhaust gases reach the end of the tube. Then, a valve shuts the tube off and prevents the exhaust gases from entering the intake manifold.

The tube connecting the intake and exhaust system is recharged with fresh air by the reverse process. The exhaust gas supply is cut off while the gas is traveling toward the intake manifold. This lowers its pressure toward the end of its "stroke." Then, relatively high pressure fresh air will push the exhaust gases back and recharge the tube. The whole system is controlled by four rotary valves, two at the exhaust and two at the intake manifolds. A large number of tubes, acting one after the other, gives a nearly continuous supply of compressed air.

Revealed also was the fact that a new test code for rating diesel engines is on its way. Already examined are better-than-present correction factors for atmospheric variations. However, a technique that is equally accurate for all types of diesels is still being sought. It also looks like a standard temperature of 85 F rather than the present 90 F will give more uniform results.

FUTURE TRANSPORTATION MEETING LOCATIONS were considered at an informal breakfast by R. R. Burkhalter, SAE vice-president for Truck and Bus Activity; C. H. Maxwell, meetings vice-chairman for Transportation and Maintenance Activity; Theodore McGill, member of the T & M Activity; and E. B. Ogden, SAE vice-president for Transportation and Maintenance Activity.

PRIMING NEW MEMBERSHIP are (left to right) SAE President W. K. Creson, Membership Committee Chairman J. H. Dunn, and Past-President W. Paul Eddy. Society membership reached an all time high this year of more than 23,000.

New Plastics, Ceramics

. . . and other materials get analysis in sharp disscussions.

A NEW acetal resin plastic was one of the new materials discussed at the meeting. Possible automotive applications include interior hardware such as door handles and window-crank handles, housings for automotive instrument clusters, and functional housings for the fuel pump, carburetor, control valves for air suspension, and the windshield wiper transmission.

In this new plastic, the formaldehyde units are combined in long, unbranched chains normally averaging more than 1000 formaldehyde units. The generic name acetal resin comes from the fact that the chain is made up of repeating carbon-oxygen units.

Because of the nature of the carbon-to-oxygen linkages in this polymer, the chains can pack closely together in a dense, uniform pattern. As a result, the chains arrange themselves into strong, solid crystals interspersed with small areas of amorphous material.

This dense crystalline structure is responsible for many of the key properties of the new resin — especially strength and stiffness, high-temperature behavior, and solvent resistance.

Another attention-getter at the meeting was a new family of fine-grained crystalline materials called glass-ceramics. Successfully used in making missile radomes, other applications under consideration include air compressor blades, abrasive binders, radar antenna housings, brake shoes, structural parts for hypersonic aircraft, piston heads, high-temperature bearings, and heat exchangers where severe abrasive conditions exist.

These glass-ceramics are resistant to high temperatures in terms both of strength and oxidation and are lighter and harder than most metals. In thermal conductivity they are classed as heat insulators. The thermal expansion coefficients range from negative values to positive values of 110×10^{-7} per deg F. Hence, extreme shock resistance may be had by choice of composition.

Glass-ceramics are classed as electrical insulators having dielectric constants from 5 to 10 and power factors at high frequencies ranging down to quite low values.

In mechanical properties these materials are generally higher in Young's modulus than glasses ranging from 12.5 to 20×10^6 psi with strengths higher than glasses and most ceramics. Glass-ceramics are not ductile or malleable as

Summer Meeting

. . . continued

are most metals, but are classed as brittle materials.

Two things are being done to properties of cast iron. First, aluminum cylinders and cylinder liners are being hard-faced by spraying with molybdenum. Second, a new hypereutectic aluminum-silicon alloy has been developed to provide the desired wear properties.

The sprayed molybdenum, which provides a molecular bond to aluminum, expands and contracts about the same as uncoated aluminum. Thus, minimum clearance need be allowed between cylinder and piston.

By supersaturating aluminum with 25% silicon, engineers claim to get an end product with wear properties as good or better than cast iron.

Direct contact between cylinder and piston (eliminating the cylinder liner) is said to be feasible when using this alloy. This development appears to bring one step closer the all-aluminum engine and appears to support the following statement from the March 1958 SAE Journal:

"The projected 12/1 compression ratio aluminum engine has shown gains which place the piston engine in an enviable position in the foreseeable future as compared with the gas turbine and free-piston types. The piston engine still is definitely in the running as a powerplant for future passenger-car propulsion."

Preventing Severe Accidents . . .

. . . related to car designers' problems. Simulators studied.

AREAS of highway accident prevention discussed at the meeting included:

- Driving simulator development.
- Effect of car design on accident severity.
- Relationship of injury to glass type and damage.

The major problem to be resolved in the design of a faithful driving simulator is simulation of the visual environment. Many approaches have been suggested; for example, the use of films, point source of light transmitted through images on a transparent screen, and the use of models. So far, none have proved too satisfactory.

The main requirement is that the driver must be able to influence his environment and vice versa. For example, when he stops, part of the world around him must stop and part of it not.

RUSSIAN RESEARCHERS are very pampered people, according to T. W. Lippert (second from left) who made a special report to the Science-Engineering Committee. Lippert, manager of sales and technical service, Titanium Metals Corp. of America, served recently on a U.S. team which visited Russian metallurgical facilities.

Listening at the Committee meeting were: (top, left to right) Dr. A. M. Rothrock, National Advisory Committee for Aeronautics; Lippert; Chrysler's C. R. Lewis, chairman of SAE's Nuclear Energy Advisory Committee; SAE President W. K. Creson; SAE Secretary & General Manager John A. C. Warner; (below, left to right) SAE Assistant General Manager Joseph Gilbert; GMC's Dr. L. R. Hafstad, SAE Science-Engineering Committee chairman; and SEC members W. Paul Eddy of Pratt and Whitney Aircraft, and Dr. Michael Ference of Ford.

Prof. Jay A. Bolt, University of Michigan (below, right), has been named to a Science Engineering Subcommittee to suggest procedures for bringing more science-oriented material into SAE channels.

P. H. Neville

MORE than 70 SAE members and their guests turned up for an 8:30 a.m. "Early Bird Breakfast" sponsored by the Production Activity.

Careful program planning, selection of an excellent subject and very effective informal presentation by participants all contributed to the outstanding success of the program. This was the first combined breakfast and technical session sponsored by an Activity in many years.

Those attending heard the highly interesting details of a crash design and tooling program for a large die casting for Chevrolet's automatic transmission.

Speaking informally and alternately for Chevrolet were R. L. Dustman, manager of production equipment; W. L. Mosher, regional plant manager, and Conrad Orloff, production engineer. Members of the Production Activity Committee who planned the meeting were P. H. Neville, Leece-Neville Co.; who served as chairman; C. W. Goldbeck, Thompson Products, Inc.; and Edward Gray, Chevrolet Motor Division, General Motors Corp. The idea for the Early Bird Breakfast was sparked by SAE Vice-President J. E. Adams and Production Vice-Chairman for meetings Andy Ashburn.

Full-scale crash studies at the University of California have provided some valuable suggestions for improving car design: For instance:

- Bumpers should be designed as collision guards and force moderators in addition to their present requirements as parking guards.
- Seats should be designed to provide support for the head and hips against lateral displacement in spin and lateral collisions.
- Such surfaces as the instrument panel, and particularly protruding knobs, should be removed entirely — or at least placed beyond contact range by the occupants during collision.

Study of the relationship between glass damage and human injuries in 715 actual accidents when glass damage occurred has yielded the following interpretations:

- Observed injuries were associated with laminated rather than tempered glass.
- The hazard presented by each glass type affected only a small proportion of the car occupants and consisted primarily of lacerative injuries.

Recent Lube Tests . . .

. . . cast fresh light on Lab-Field correlations.

TESTS aiding lubricating oil performance studies include:

- Simplified shear stability test.
- FL-2 test modified to allow a correlation between laboratory and field performance of oils.
- Oil consumption tests using laboratory engines having external sumps.

Simplicity of design and operation, and the need for but a small sample of oil are obtained by using a fuel injector in the new shear stability test. Correlation with field data is not exact, but it appears to be as good as that of many more involved versions.

Improvements in gasoline-engine lubricating oil detergency can now be determined quickly. The FL-2 test is increased in severity by using a special reference gasoline that forms heavy piston varnish with conventionally com-

SMALL ENGINE PROBLEMS brought a spirited exchange between users and manufacturers at a session arranged by the Transportation and Maintenance Activity and chairmanned by SAE Past Vice-President for T & M F. K. Glynn. Peter Altman, SAE presidential advisor on small engines, acted as secretary for the session and assisted in development of the program.

Specific needs for trailer refrigeration small-engine units, it was brought out, revolve around installation and operating problems. Specific needs noted are:

- Improved automatic stationary devices.
- Increased oil capacity for economical maintenance.
- Better air filters.
- Greater operating life between overhauls.
- Written specifications for users.
- Better maintenance instructions.

F. K. Glynn

GASLIGHT GAYETIES, under the guidance of Entertainment Committee Chairmen Alice and Wayne Goodale (shown at left), drew nearly 300 gaslighters, Gibson girls, and bicycle-built-for-two enthusiasts.

BARBER SHOP QUARTET WINNERS at the Gay Nineties party were Detroit Section Songsters G. E. Saxon, Robert Falberg, H. T. Niles, and T. J. Wilkinson.

Summer Meeting

. . . continued

pounded MIL-L-2104A oils. Correlation of FL-2 varnish and field deposits obtained during stop-and-go driving is valid as long as the oil has no peculiar deposit-forming characteristics. If so-called "lead paint" deposits form, another test must be used.

One-third to two-thirds of the oil consumed by an engine is lost through the valve assembly. This was one of the results coming from oil consumption tests with engines equipped with external oil sumps, providing separate cylinder and overhead valve lubrication systems. It was also found that, although viscosity is the most important property affecting oil consumption, over one-third of the reduction generally obtained by going from SAE 10 to SAE 30 oil is due to the decrease in oil volatility.

New Troubles Come with Help . . .

. . . which nuclear developments bring to automotive areas.

DEVELOPMENTS in the nuclear field are helping to improve some old arts, but they are also providing industry with some new problems.

As an example of the former, there is the excitation of phosphors by radiations from radioactive material to produce sources of light. This art is as old as the history of radioactivity itself. But the use of gaseous radioactive isotopes (which are byproduct fission materials of the nuclear energy program) has led to the development of phosphor light sources having brightness levels many times that of earlier materials. For example, light sources, using one-tenth to one-third the radioactive gas required in the brightest sources available only a year ago, and also several times brighter than the higher-gas-content sources, have been produced — and the upper limits of brightness attainable are not yet in sight.

Uses for these self-energizing sources include photocell activation; escape hatch, emergency exit, and instructional markers for aircraft; airstrip markers; light sources for illuminating in-flight refueling equipment.

Latest development is a high-intensity white light source with color filters. This makes it possible to produce any color of the visible spectrum.

One of the problems — that of developing lubricants capable of resisting various types of nuclear radiation — is yielding to intensive studies.

It appears that radiation damage to both base stocks and finished products involves viscosity changes, loss of oxidation stability, and development of corrosive tendencies.

This work showed that a beta source from a Van de Graaff accelerator can be used for screening lubricants. The damage caused can be related to that obtained under exposure to mixed gamma and neutron radiation in a nuclear reactor.

THE BOPPER — a device developed by the USAF Aeromedical Laboratory for simulating car crash deceleration with human subjects — was demonstrated during the meeting. The human volunteer is strapped into the seat, propelled by a shock-cord catapult to 15 mph, and then the device is brought to a stop with mechanical pinch brakes. Maximum acceleration of 22**g** is attained in 0.035 sec. Total trip takes 0.065 sec.

ARTHUR J. DAVIDSON, JR.
1958 Golf Champion

MET SECTION HELLO PARTY was enjoyed by more than 275 SAE members and guests. Serving on the Reception Committee with Metropolitan Section Chairman S. G. Tilden, Jr. (right) and C. M. Larson (left) was M. G. Beard.

COMPREX DIESEL SUPERCHARGER is inspected by (left to right) Session Secretary W. J. Pelizzoni, Max Berchtold, and Chairman H. G. Braendel prior to the Diesel Supercharger session. Berchtold presented a paper which described the supercharger as being able to deliver high air density over a wide engine speed range. It also permits immediate load changes without lag and smoke.

SEAT BELT DISPLAY — A commercial-type seat belt mounted to a 19-gage "floor pan metal" sample which withstood 6700-lb static loop load without failure last year is shown at left. At right is an actual floor pan section with a USAF lap belt which held a 220-lb dummy while a salvaged 1951 Chevrolet staff car impacted a solid concrete barrier at 30 mph.

PYROCERAM

—A New Family of Glass-Ceramics

Based on paper by

Dr. W. W. Shaver and Dr. S. D. Stookey
Corning Glass Works

PYROCERAM signifies a new family of fine-grained crystalline materials called glass-ceramics. These materials are made by a process of controlled crystallization from special compositions containing nucleating agents.

Glass-ceramics appear worthy of attention for their basically new manufacturing process; for their new and useful combinations of properties; and for the broad range of potential compositions and properties open for exploration.

Manufacturing Process

The batch ingredients, including the nucleating agent, are mixed and melted to a homogeneous molten glass. Depending on the composition, the glass may be nearly as fluid as molten metal or extremely viscous. The glass is held uniform in composition by stirring and other methods.

The molten glass is formed by conventional glass-forming methods, such as pressing or blowing into molds; drawing as tube, rod, or pipe; rolling or drawing into flat sheet; or centrifugal casting. The more fluid glasses may be cast into intricate shapes by methods similar to metal casting.

The glassware then is cooled. At this point it is transparent, and can be readily inspected for flaws or bubbles.

A carefully controlled high-temperature heat treatment causes first the precipitation of billions of submicroscopic crystal nuclei; then growth of these nuclei until the glass article is converted substantially unchanged in size or shape to the fine-grained crystalline product Pyroceram. The crystals of Pyroceram are normally smaller than 0.0001 in. in diameter, and are randomly oriented. Usually a small proportion of glass is interspersed with the crystals.

Although it is possible to reproducibly form glass-ceramic articles to reasonably close tolerances requiring no further finishing, some high-precision shapes do require finishing. Glass-ceramics are capable of being ground and polished to very accurate dimensions by the methods used for glasses, ceramics, and hard metals.

Properties

Glass-ceramics are nonporous and generally have an opaque white appearance in the finished state, although some compositions may also be transparent like glass. They are like glasses in their ability to resist chemical attack with measured durabilities in weight loss ranging in values comparable to the durable chemical glasses. They are resistant to high temperatures in terms both of strength and oxidation. They are lighter and harder than most metals. In thermal conductivity they are classed as heat insulators. The thermal expansion coefficients range from negative values, through zero, to positive values of 110×10^{-7} per deg F. Hence extreme shock resistance may be had by choice of composition.

Glass-ceramics are classed as electrical insulators having dielectric constants from 5 to 10 and power factors at high frequencies ranging down to extremely low values.

In mechanical properties these materials are generally higher in Young's modulus than glasses, ranging from 12.5 to some 20×10^6 psi with strengths higher than glasses and most ceramics. Glass-ceramics are not ductile or malleable as are most metals, but are classed as brittle materials.

Various compositions can be tailor-made to meet desired properties, with the final control depending on special heat treatment. Two compositions in various forms and types of product are now available commercially. These have code numbers 9606 and 9608 and their properties are listed in Table 1 together with values for two commercial glasses and high-purity alumina for comparison.

Properties of Pyroceram 9606 indicate that it is suitable for high-temperature, high-frequency applications in the electronics field. The maximum useable temperature under load is 1560 F for 1000 hr. This glass-ceramic has been successfully used as a missile radome. Its hardness and ability to withstand high temperatures makes it suitable for consideration as an abrasive binder and for bearing parts.

Special glass-melting techniques are used on Pyroceram Code 9606 to assure uniform composition, constant density, freedom from bubbles and striations, and uniform electrical properties. Code 9606 is most easily formed by gravity and centrifugal casting. With certain limitations, it can be pressed and rolled.

Pyroceram Code 9608 is a white, opaque fine-grained crystalline material with high mechanical strength, extremely low coefficient of thermal expansion, and a hardness substantially higher than that of glass. Developed primarily as a general-purpose material, Pyroceram Code 9608 can be formed by all automatic glass manufacturing processes. It can be blown, drawn as tubing, pressed, and rolled.

The hardness and low expansion coefficient of Pyroceram Code 9608, plus its ability to be easily

Table 1—Comparison of Properties of Pyroceram with Glass and Ceramics

	Glass-Ceramic Pyroceram		Glass		Ceramic
	9606	9608	Code 7900 96% silica glass	Code 7740 borosilicate glass	High-Purity Aluminas
General					
Specific Gravity, 77 F	2.60	2.50	2.18	2.23	3.6
Water Absorption, %	0.00	0.00	0.00	0.00	0.00
Porosity (Gas Permeability)	gas tight	gas tight	gas tight	gas tight	gas tight
Thermal					
Softening Temperature, F	2282	2282	2732	1508	3092
Specific Heat, 77 F	0.185	0.190	0.178	0.186	0.181
Mean Specific Heat, 77 F–752 F	0.230	0.235	0.224	0.233	0.241
Thermal Conductivity (77 F Mean Temperature), Btu/hr-ft-F	2.10	1.13	—	0.626	1.25–1.40
Linear Coefficient of Thermal Expansion $\times 10^7$, 77 F–572 F	31.6	3.9–11.1[a]	4.45	17.8	40.5 (68 F–932 F)
Mechanical					
Modulus of Elasticity, psi $\times 10^6$	17.3	12.5	9.6	9.5	40
Poisson's Ratio	0.245	0.25	0.17	0.20	0.32
Modulus of Rupture, abraded psi $\times 10^6$	20	16–23	5–9	6–10	40–50[b]
Hardness					
Knoop, 100 g	698	703	532	481	1880
500 g	619	588	477	442	1530
Electrical					
Dielectric Constant					
Frequency $\times 10^6$, 77 F	5.58	6.78	3.8	4.6	8.81
572 F	5.60	—	3.9	5.9	—
932 F	8.80	—	—	—	9.03
Frequency $\times 10^{10}$, 77 F	5.45	—	3.8	4.5	8.79
572 F	5.51	—	—	—	—
932 F	5.53	—	—	—	9.03
Dissipation Factor					
Frequency $\times 10^6$, 77 F	0.0015	0.0030	0.0005	0.0046	0.00035
572 F	0.0154	—	0.0042	0.0130	—
932 F	—	—	—	—	0.012
Frequency $\times 10^{10}$, 77 F	0.00033	—	0.0009	0.0085	0.0015
572 F	0.00075	—	—	—	—
932 F	0.000152	—	—	—	0.0021
Loss Factor					
Frequency $\times 10^6$, 77 F	0.009	—	0.0019	0.0212	0.0031
572 F	0.086	—	0.0164	0.0566	—
932 F	—	—	—	—	0.108
Frequency $\times 10^{10}$, 77 F	0.002	—	0.0036	0.282	0.0132
572 F	0.004	—	—	—	—
932 F	0.008	—	—	—	0.019
Volume Resistivity					
Log_{10} ohm-in 482 F	9.6	7.7	9.3	7.7	13.6 (212 F)
662 F	8.2	6.4	7.7	6.2	12.5 (572 F)

[a] Depending on heat-treatment.
[b] Unabraded values.

formed, have brought the material to the attention of bearing manufacturers. Tests indicate Pyroceram 9608 bearings will operate under varying conditions at temperatures as high as 1000 F, at loads approximately half that expected of standard steel bearings. The advantage over steel is that Pyroceram bearings under actual running conditions will operate at high temperatures without corrosion, deformation, and softening.

Applications and Directions of Future Development

This new field of materials obviously opens many opportunities for applications where presently available materials are unsatisfactory. Applications now under consideration include such products as air compressor blades, abrasive binders, radar antenna housings, brake shoes, structural parts for hypersonic aircraft, piston heads, high temperature bearings, and heat exchangers where severe abrasive conditions exist.

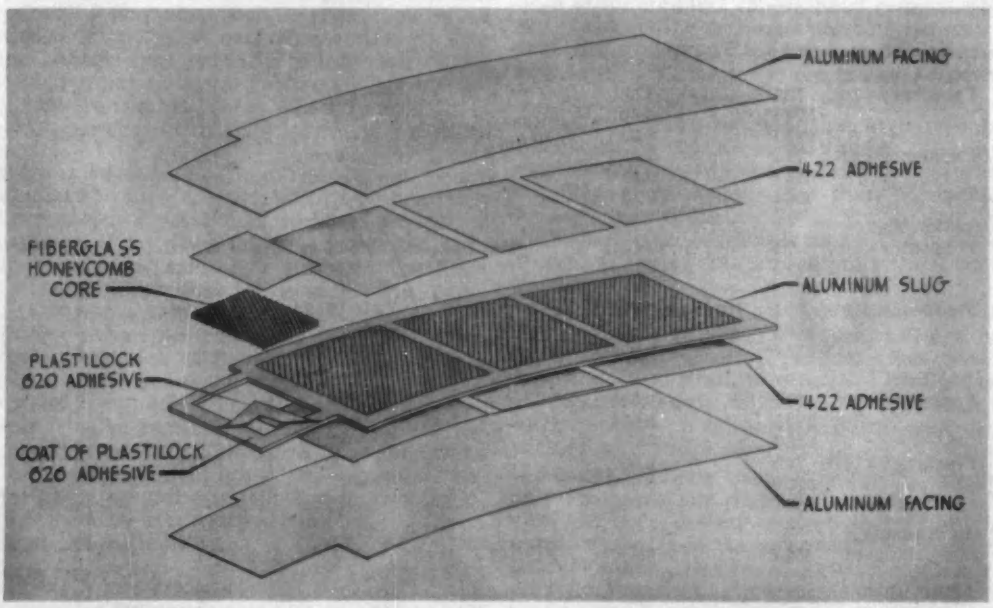
Recent laboratory developments give promise for the near future of substantial increases in mechanical strength at temperatures up to at least 2200 F; increased hardness and wear resistance; tailor-made compositions having a range of expansion coefficients to match various metals; and transparent materials many times stronger than present glasses. These Pyroceram materials with their variety of forms and combinations of properties undoubtedly will find application in process and service functions providing better performance and lower cost. They provide a new opportunity to reconsider industrial processes with the possibility of answering unsolved problems or developing better methods to accomplish the desired result.

To Order Paper No. 60C . . .
. . . on which this article is based, turn to page 5.

B-58 Wing Panels . . .

. . . are a sandwich of glass-fiber honeycomb between aluminum sheets. Resultant structure is very light, very stiff, very strong, and does not buckle under the high temperatures imposed by aerodynamic heating at supersonic speeds. Besides, insulating properties of the glass-fiber honeycomb keep the heat from reaching the fuel inside the wing.

Based on talk by **T. G. Pownall,** Convair (Presented before SAE Cincinnati Section)



OUTER PANEL of aluminum, inner core of high-temperature-resistant honeycomb, and inner skin of aluminum alloy are put together with adhesive sheets and cooked in what Convair shop men call a "pants presser" (because that's what it looks like).

Abridgment of an

SAE Metropolitan Section paper

Brake Development . . .

. . . paced by traffic needs. Design controls input; maintenance controls output, and both are headed for improvement.

Based on paper by

William Tauss,

Grey-Rock Division, Raybestos-Manhattan, Inc.

PROPER maintenance and design are both needed for good brake performance. Better preventive maintenance programs and inspections are helping the first, while supplementary brakes, new materials and techniques will improve the future design.

Heat fade and lining life can be improved by:

- Balanced brakes.
- Total contact.
- Rapid heat dissipation.

The internal 2-shoe brake with one forward-acting and one reverse-acting shoe is the most popular for heavy-duty service because it is simple and reliable. But its output is comparatively low because the reverse-acting shoe is unenergized. To overcome this condition manufacturers have offered brakes with two forward-acting shoes. This in itself will increase brake output by 50%.

Brake Linings

Linings made with resin binders are generally less resistant to heat than metallic or ceramic-metallic combinations. Under test, the full phenolic resin compound shows the greatest loss in coefficient of friction after reaching 500 F. It drops from a maximum of 0.45 to a leveling-off point of 0.35. A compound containing a minimum amount of resin has a higher coefficient at both the start and finish of the test. It levels off at approximately 0.45 after reaching 500 F. Although apparently good for high-temperature conditions, this material gives an erratic performance. It will tend to score brake drums at temperatures of 900–1000 F because the brake drum material will soften, whereas the lining will not.

Sintered iron has the lowest coefficient of friction of the three types of material, but it is uniform at high temperatures. It does require a higher brake input. Among the sintered metal friction materials are also sintered bronze, or combinations of it with ceramics. For the most part they are brittle and hard to handle without breaking. They have little or no flexibility and may crack, flake, or chip with flexing of the shoe or plate.

Rapid Heat Dissipation

One method of reducing the heat load on heavy-duty brakes is to install a unit known as a hydro-tarder and connect it to the propeller shaft. It is similar to a water dynamometer in manner of operation. Another method is to use an electrical generator, also connected to the propeller shaft, which transforms the kinetic energy of the vehicle into heat and dissipates it into the atmosphere from heating elements.

Still another method, showing great promise, is a brake under development at Raybestos-Manhattan. The design is based on four known facts:

1. A pound of water will store as much heat as 9 lb of iron with the same temperature rise.
2. Water or coolant can be pumped through a heat exchange with ease.
3. Copper has eight times the conductivity of iron.
4. Water converted to steam will absorb 10,000 times the heat that iron will at the same temperature.

How the Water-Cooled Brake Works

This brake can be designed as a disc, propeller-shaft, or 4-wheel brake unit for any vehicle. It is similar to internal-shoe drum brakes in appearance, but the lining is removed from the shoes and put on the inside of the brake drums. The brake shoe surfaces are made of a copper or bronze compound with cores of water passages running through them. The copper working surface of the shoe operates against the friction material inside the drum. The heat developed is transmitted through the shoe to the cored passages, which are filled with water. The shoes are connected by piping to the radiator of the vehicle, where the heat is removed from the coolant, which is then recirculated to the brake shoes.

Tests indicate this brake to be capable of absorbing and dissipating heat in excess of any possible need. Moreover, one water-cooled brake of this design can do the work of at least five conventional brakes of similar size. For this reason, wear on the brake lining will be about 10% of that expected from the average conventional brake.

To Order Paper No. S82 . . .
. . . on which this article is based, turn to page 5.

Modulator Reverser Control

Tames Jet Thrust

Based on paper by

John Burnette and Donald Moses

Vickers, Inc.

FULL benefit from thrust reversal systems can be achieved with in-flight modulated reversers. Such systems can be used for landing-runs and approaches to airports where jet planes operate. Limited systems can also be used, such as a full reversal landing-run only or a 3-position in-flight system. However, a completely modulated system can be controlled to give all the operating characteristics desired. This is done independent of engine controls.

Controls for In-flight Scheduling

The modulated system is a closed-loop positional servo operating the reverser actuator in proportion to the pilot's control lever. In multi-engine planes two symmetrical engines are coupled so their actuators move simultaneously.

In the servo system, the input signal is compared to the position feedback signal from the actuator. The resulting signal is fed to a magnetic amplifier used for positioning the actuator control valve. The symmetrical engines are kept synchronized by comparing the position feedback signals of the two engines. Any error in relative position of the engine reversers will initiate a corrective signal to each engine's amplifier.

To start a thrust reversal the pilot first turns the intent switch on. This pressurizes the system by the action of an electrically depressurized pump. When system pressure is up, a switch closes which permits an amplifier to send signals to the reverser actuator (See Fig. 1.) The pilot's movement of the control handle results in movement of the control

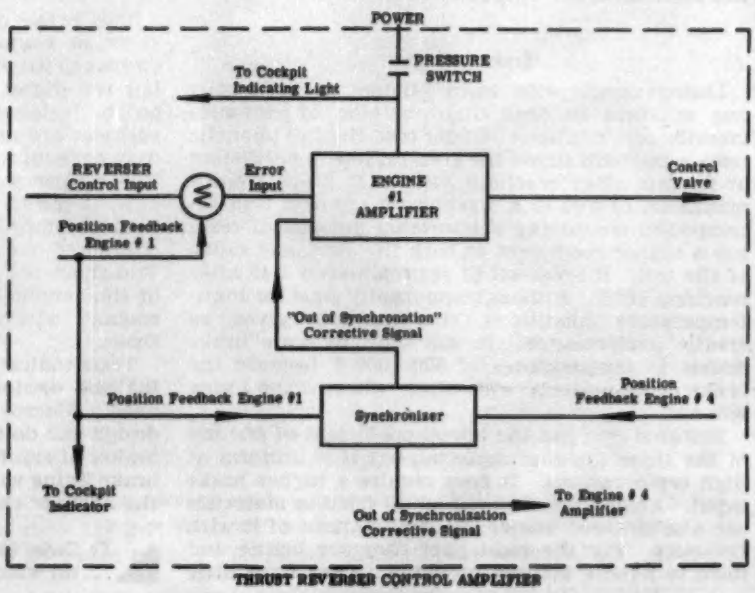


Fig. 1 — One amplifier for each engine and one synchronizer for each pair of engines are needed for a fully modulated thrust reverser system.

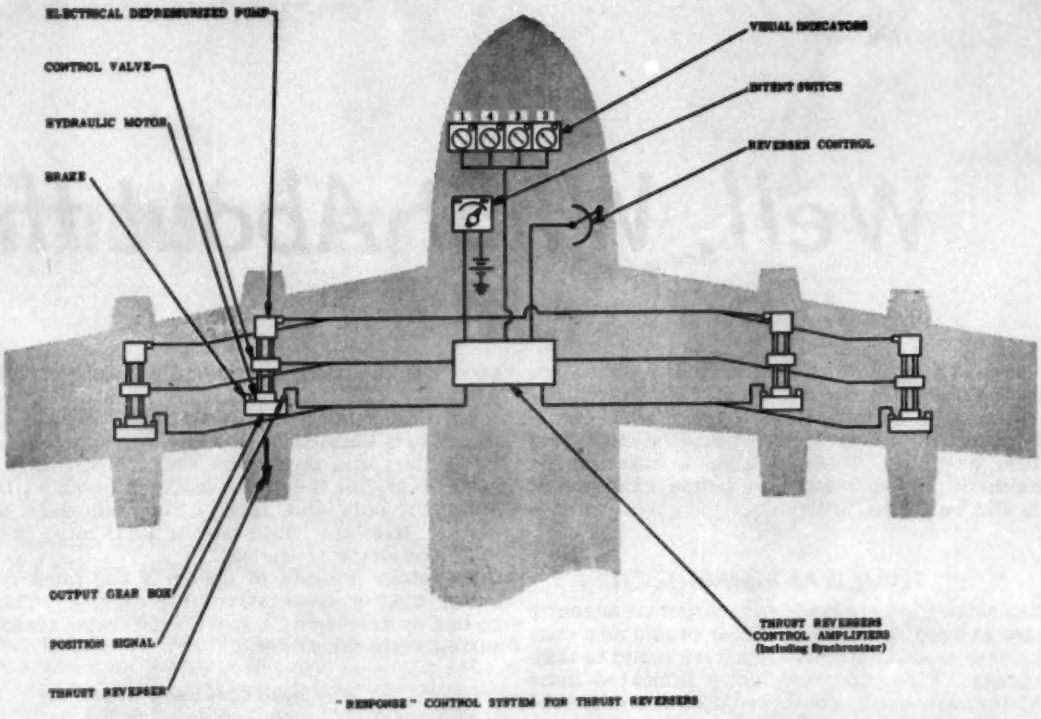


Fig. 2 — A fully-modulated thrust-reverser system feeds back the reverser position so matched engines can be synchronized. With this system the pilot can select any percentage of thrust reversing. Arbitrary reverser limits can be built into the system.

valve which unlocks and positions the actuator. The control valve will close when the desired position of the reverser is reached and the brake will relock. If at any time the two engines become too far out of synchronization the amplifiers will make the complete system inoperative.

The pilot has a reverser position indicator for each engine and a light to indicate the system is functioning. (See Fig. 2.)

Actuating the Reverser

The system designed was based on the following requirements:

- Full modulation.
- Multi-engine airplane.
- In-flight or high-power initiation.
- 10,000-lb reverser load.
- 6 in. per sec rate of actuator travel.
- 300 F accessory and 700–1000 F reverser section temperatures.
- Reverser extension time — 5 min per hr.

A hydraulic actuator is preferred because it does not bleed air from the engine compressor during the landing-run. In this condition the engine has a low bleed pressure while the actuator is moving high loads.

The power supply system is a variable displacement hydraulic pump designed as an engine component. During periods of nonreversing the pump operates as a fixed displacement unit delivering cooling flows of 5–10% of maximum delivery at 100–200 psi. When the intent switch is on, the pump becomes a constant-pressure variable-delivery unit and provides maximum pressure to the control valve.

The actuator portion of the circuit consists of a reversible, fixed-displacement, piston-type, hydraulic motor and four screw-jacks. The jacks are driven through a gearbox and four low-torque, high-speed flex shafts. (If extremely accurate positioning is needed, the flex shafts could be replaced with torque tubes.) The gearbox incorporates a hydraulically operated spring loaded mechanical lock and positional feedback for the control network.

The mechanical lock will hold a position against any load experienced during the reversing regime. The lock does not release unless power is available to complete the motion scheduled.

The closed system approach was chosen because it is independent of the power control system and has a steady heat rejection of one-tenth of the 50 Btu per min heat rejection rate of a continuous constant-pressure system. Also, only dry mechanical parts are used near the reverser so the hydraulic components do not suffer from excessive temperatures.

To Order Paper No. 49C . . .
. . . on which this article is based, turn to page 5.

Well, What About the

ONE model of car cannot possibly fulfill all design requirements to their maximum. Any given design emphasizes certain characteristics while minimizing others. During development the car's personality, like that of an infant, is affected by environment and heredity. A prime example of this is the European minicar.

Putting It All Together

When attempts were made to incorporate as many features as possible into a small car design as a case study, three main characteristics were found to take precedence. First, the fun factor indicated light weight through small size to avoid excessive horsepower requirements; short-distance driving reaffirmed the need for small size, and prestige value became doubly important to overcome the "puddle-jumper" reputation. This last was found best handled by incorporating a certain amount of flare to elevate the car psychologically.

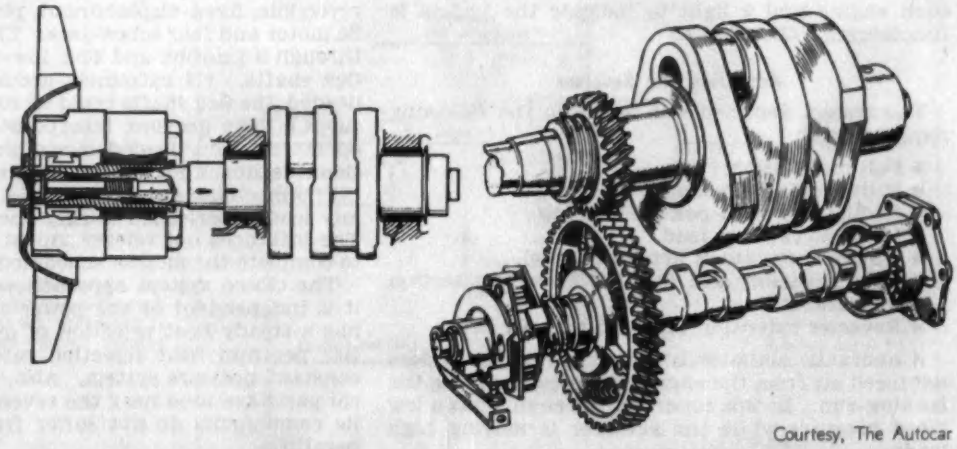
For full enjoyment a driver should feel himself an integral part of the machine. This eliminates all power extras and current seating practice. Firm, smooth support with no side shifting of the torso is needed. Requirements of the human form establish good design. Convenience of controls is also important.

Existing small cars are at least as safe as the larger cars because of unitized construction, effective pillars and posts, and absence of overly large glass areas, but they seem more vulnerable. Design must not only give safety, but seem safe to the owner. Here the subtle line is what must predominate the shape of the car.

To retain honesty of design a car must possess better than average structural rigidity. This can be had by developing a space-tube frame completely surrounding the driver.

Why Small Cars Came About

The Europeans undoubtedly emphasize somewhat different aspects of design. Many cannot afford any vehicle larger than a minicar. As a worker's economic status improves, he moves from a bycycle to a motor scooter and from a scooter to a minicar. Minicar sales have skyrocketed overnight. But the European economy may already be leaving the minicar behind, as evidenced by the bringing out of larger and more powerful versions. A still better economic climate may spell the doom of the minicar.



Courtesy, The Autocar

Fig. 1 — Citroen 2CV generator has no bearings. Fan and generator armature are bolted to front of crankshaft; generator stator is bolted to crankcase. One-piece connecting rods are assembled over the crank pins on front and rear sections of crankshaft, then the two crank pins are forced into oval central web. Oil pump is driven from rear of camshaft, the ignition contact breaker from the front. There is no distributor and spark plugs fire on both power and exhaust strokes.

Abridgment of

SAE Detroit and Rochester Section Papers

Small Car?

In many instances European small cars appear grotesque and their overall performance generally is substandard to our needs. But European sales leaders have begun to answer partially the aforementioned classifications of American requirements. And if an American manufacturer should analyze these requirements closely and base a small car design exclusively on *our* needs, his sales success might mark an automotive milestone.

Don't Sneer at the Minicar

Even though the minicar may seem grotesque and its market here severely limited, it would take a very sophisticated engineer to deny the technical interest of these amazing small vehicles. The designer's ingenuity has been challenged by a very modest performance demand on the one hand and by very stringent cost limitations on the other; he has risen to the occasion with a hatful of tricks. Consideration of design requirements with actual examples of meeting them will reveal what these tricks are.

Manufacturing Cost — Volume is small and competition intense. To sell at all the price must be

The information in this article is based on the following papers:

"Factors Influencing Small Car Design" (Paper No. S95)
Alan P. Anderson, Ford Motor Co.

"Minicar — Evolution or Revolution" (Paper No. S97)
David L. Cohoe, Chrysler Corp.

"Small Car for the American Market" (Paper No. S96)
Robert F. Jenson, American Motors Corp.

To Order Papers No. S95, S96, S97 . . .
. . . on which this article is based, turn to page 5.

FIAT 500

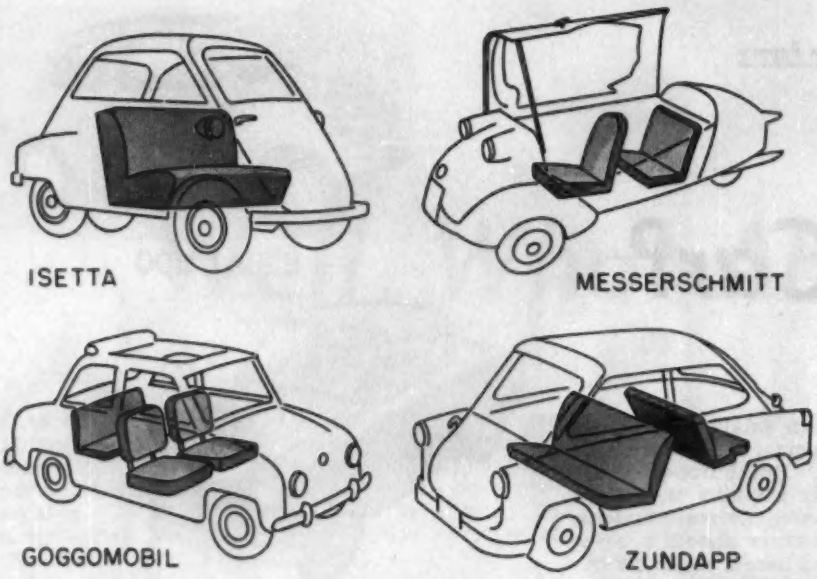
GOGGOMOBIL COUPE

BMW ISETTA 300

CITROEN 2CV

Courtesy, The Autocar

MEADOWS FRISKY



SEATING ARRANGEMENTS – FOUR GERMAN MINICARS

Fig. 2 — Varied seating arrangement typical of minicars.

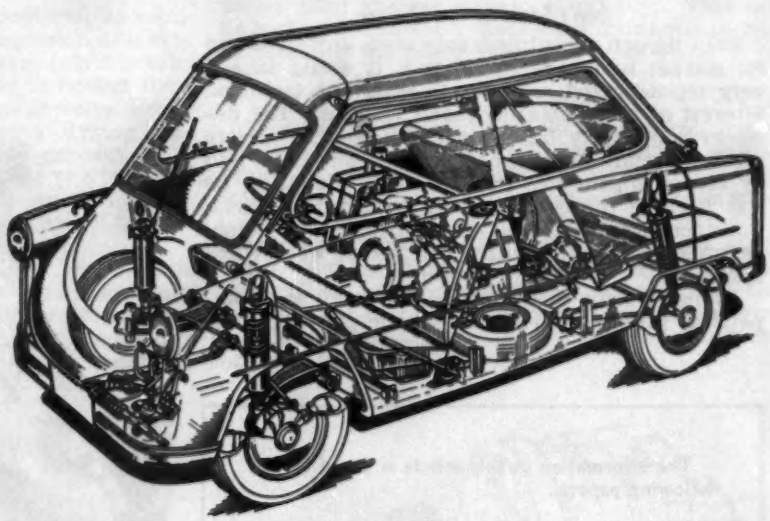


Fig. 3 — Zundapp engine is placed between front and rear seats.

Well, What About Small Cars?

continued

low, yet buyers demand quality and durability. Costs must be analyzed and controlled carefully.

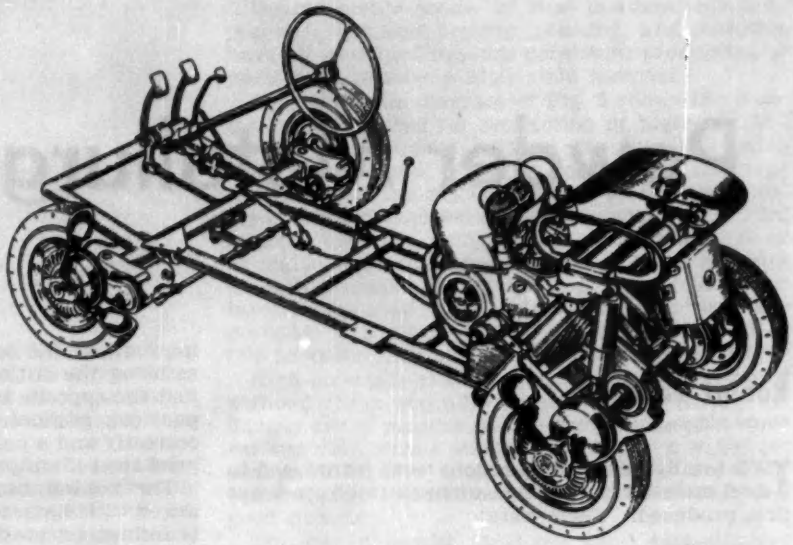
Weight — Overall weight must be held to a minimum to keep raw material costs low and aid in getting maximum performance. Light alloys should be considered for those applications where an increase in performance and/or reduction in fabricating cost will offset material cost.

Number of Passengers — Two adult passengers must be accommodated. Occasional accommodations for two more adults is desirable so that four can be carried in moderate comfort for short distances.

Performance — A top speed of 50–60 mph is obligatory and the sustained cruising speed should equal or approach it. Gear ratios must give the best possible acceleration, hill climbing, and road-load fuel economy consistent with engine capabilities.

Engine — By definition, 500 cc is the displacement for a minicar engine and it is adequate. The engine may be one cylinder or two. It will be aircooled for light weight and low cost fabrication (Fig. 1). Since it is so small its location in the vehicle is arbitrary and this one factor explains the varied body and/or seating configurations of the minicar. Examples of seating arrangements are shown in Fig. 2. The Zundapp has its engine placed between the front and rear seats (Fig. 3).

Number of Wheels — Though saving on one wheel and tire, the 3-wheeler overall width will be greater



Courtesy, The Motor

Fig. 4 — Meadows Frisky engine is located ahead of narrow-tread chain-driven rear axle with crankshaft centerline parallel to axle. To reverse, the 2-stroke engine is run backwards. One of the rear brake drums is a dummy, it being thought adequate to brake one wheel since there is no differential.

than the 4-wheeler for the same wheelbase and equivalent stability. The increased frontal area means more engine output for equivalent performance, and the loading platform is inadequate for four passengers.

Power Train — A 4-speed transmission is needed. If the engine is a 2-stroke, it may be possible to run the engine backward to eliminate the reverse gear. The Meadows Frisky illustrates this feature (Fig. 4). The ideal is to locate the engine, clutch, transmission, and differential so as to eliminate need for a propeller shaft. The Fiat 500 engine is coupled directly to the transmission-differential assembly.

Suspension — European roads make a 4-wheel independent suspension highly desirable, despite a cost penalty. One example is the Meadows Frisky (Fig. 5).

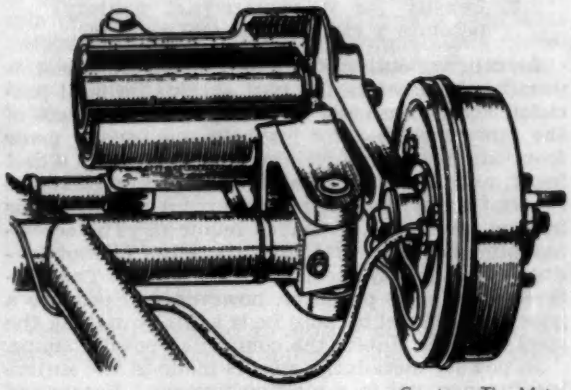
Body Construction — The unitized body will appear to be ideal in view of:

- Need for minimum weight.
- Small overall dimensions.
- High proportion of total enclosed volume occupied by passengers and opportunity to eliminate front-end sheet metal and separate frame.
- Relatively low stresses.

Styling — Little cars for big people pose a problem. Luckily the buyer likes functional styling with its combination of simple surface contours, maximum panel interchangeability, and minimum ornamentation, which gives a charm of its own and reduces tooling costs. Designs are clean aerodynamically, which aids performance and economy.

Small Car for American Market

When Nash introduced the forerunner of the Metropolitan, the experimental NXI in 1950, its appearance was similar to a minicar, but the design was modified to meet American conditions. The NXI was proposed as a 1000-lb vehicle, lighter than the Rambler (still under wraps), 16 in. shorter in wheelbase and nearly 3 ft shorter overall. The engine was to be either 18 or 36 hp.



Courtesy, The Motor

Fig. 5 — Meadows Frisky front suspension is of the Dubonnet type with leading arms, but rubber in torsion is the springing medium. Note the small coil springs, which act on the disc interposed between arm and suspension casing to provide friction damping.

Questionnaires circulated to get public reaction brought these suggestions predominantly:

- Leave front seat cushion undivided to accommodate three people.
- Widen the tread. It was then 47 in. in contrast to the average 57 and 58 in.
- Increase wheelbase 5 or 6 in.
- Put auxiliary seat in rear.
- Use the 36-hp engine even if the penalty is 10 mpg for an added 5-mph top speed.

Some of the suggestions were ignored because it was deemed inadvisable to have dimensions approach too closely those of the still-to-be announced Rambler. A 42-hp Austin engine was adopted, overall length was increased 4½ in., weight raised from the projected 1350–1450 to 1875 lb, wheelbase was only an inch longer, tread 2 in. less, overall width ½ in. less, and height 1½ in. more.

Powder Metallurgy Comes

Based on paper by

Robert Talmage
Powder Metallurgy Consultant

TWO totally new considerations were introduced to steel metallurgy 20 yr ago when sintered steel was first produced. These were:

1. The precision shape of a part can be established prior to the making of steel.
2. Density (or its counterpart porosity) becomes a variable physical property.

In other metal-working processes, the steel is usually made before the part obtains its final precision shape, normally by machining. Products of the screw machine, for instance, are usually made from bar steel which has been produced from a cast ingot, and its mechanical properties are therefore determined by the steelmaker, except for variations in heat treatment, if that is required. The screw-machine parts manufacturer, therefore, cannot produce poor quality steel in his product. The sintered-steel parts producer, however, can produce a poor quality steel because he is actually making the steel when he sinters the compacted powder shape.

In powder metallurgy steel is made in the sintering furnace, not in a melting furnace. Because of this, parts producers are steelmakers and many, even today, do not realize this or the importance of it. The normal feeling of most people is to regard the sintering operation as just another heat-treating method and consider the compacting operation as being the critical part of the process. Actually, just the opposite is true because even the best compact can produce poor quality steel if sintered incorrectly and a poor compact can produce relatively good steel if sintered correctly.

The second basically new consideration introduced with sintered steel was variable density which is influenced mostly by the compacting operation. Within certain limits, the density of sintered steel varies directly with the compacting pressure used and, in general, so does its strength.

In liquid metallurgy, porosity is always looked upon as a defect and this same idea is often transferred to sintered parts, whereas actually it should be regarded as a distinct advantage and not as a disadvantage.

The size and distribution of the porosity can be varied, and with good techniques it is always uniform and interconnected. Thus it can serve as a sponge to absorb lubricants, plastics, or lower melting point metals. This ability to produce unusual combinations of metals and nonmetals is daily solving problems of wear and heat resistance which have heretofore been thought impossible.

Comparison of Average Mechanical Properties
(Cold Drawn 1020 Steel and .7C-5Cu Sintered Steel)

	1020 Cold Drawn Steel*	.7C-5Cu Sintered Steel
Tensile Strength — psi	75,000	75,000
Yield Strength — psi	63,700	75,000
Elongation — %	20	1
Hardness — Rockwell B	82	86
Density — g/cc	7.86	6.6

* Metals Handbook p. 537

properties of sintered steel

Table 1 compares the properties of a high copper (5%) — high carbon (0.7%) sintered steel with that of normal cold drawn 1020 stock. Note that greater yield strength and equivalent hardness is obtained with the sintered product. This is due to the high carbon content. Low carbon standard steels are normally specified in most mechanisms because they are lower in initial cost and easier to process. With sintered steel, high carbon content can be provided just as cheaply as low carbon.

The high carbon content and the interconnected porosity, however, serve to keep the elongation low. This is often felt to be detrimental because it is so much lower than standard steel. Actually, it usually isn't detrimental, however, since most parts are usually pressed to final shape and no drawing or bending operations are required which need stretchability. This does not mean that good ductility is impossible to produce because elongations of 5% or more are possible when the carbon content is reduced.

sintered steel gears

As an example of the type of application where ductility means little, and yield strength is all im-

# of Age

portant, a gear can be considered. Here the part will fail in service whenever a tooth is stressed beyond its yield strength and it doesn't matter much if it breaks, or just bends, because in either case the gear will not function.

The production of gears from sintered steel represents the largest single type of structural part made and the quantity probably exceeds one million per day. Practically all types are produced including spurs, helicals, bevels, face, cluster, partial, and skip tooth. Single and multiple holes are of various types including tapered, counterbored, keyed, keywayed, splined, square, and eccentric. Many of the large variety of shapes and sizes are shown in Fig. 1, all of which have been produced without any machining. They are used in all kinds of mechanisms from clocks to automobiles and from toys to business machines.

Production of these gears by the powder metallurgy process is cheaper than any other method of production. The pieces shown are examples of powder metallurgy substitution for such methods of fabrication as stamping, die-casting, forging, sand casting, permanent-mold casting, screw-machining, and hobbing. Besides reduced cost, greater precision and better wear resistance is also obtained in many cases.

Improvements made in raw powders, blending practice, mixtures, tooling, pressing, and sintering have all combined to allow consistent production of parts with relatively high yield strengths.

The schematic diagram of Fig. 2 shows the basic methods now used for production of high-strength gears. The simplest method requires the three basic operations of blending, compacting, and sintering. A second method utilizes a sizing or coining operation to decrease the tolerances. The third method uses the principles of the production of wrought steel by cold working the sintered compact at high pressures and reheating. The fourth one involves the casting of a cuprous material into the porosity of a sintered steel compact. The latter two processes can produce high-strength steels.

High-strength steel, however, can be produced without these secondary operations. Within the density range possible in one compaction of a typical material, tensile strengths of 40,000 to 90,000 psi are possible. The high strength is the result of three things — good materials, good pressing, and good sintering.

The use of copper (5%) as a low cost alloying agent coupled with a relatvely high carbon content of 0.7% produces an excellent combination to obtain relatively high yield strengths plus good wear resistance. These are the two requirements necessary in most critical applications since gear mechanisms usually fail by wearing out or overloading.

The reasons for good wear resistance are:

1. The alloy has practically no ferrite present when sintered correctly.
2. The surface has a finish equivalent to one that is lapped.
3. Small surface pores are present to help support lubricant films and supply them, if necessary.

Control of material analysis is not enough to assure the production of uniform high-quality gears.

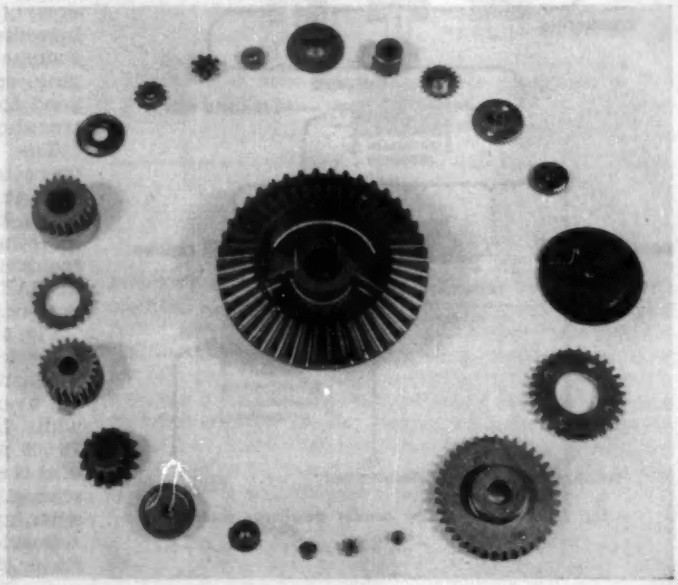


Fig. 1 — Typical sintered steel gears. All have been produced without the need for machining.

• • • Powder Metallurgy Comes of Age

— (continued)

The manufacturing factors which are necessary to successfully and consistently obtain uniform high-quality gears are:

1. Proper selection of raw materials.
2. Accurate weighing of each ingredient of the powder mixture selected.
3. Good blending of the various ingredients forming the compact.
4. Accurate compacting with high quality tools.
5. Uniform sintering under closely controlled conditions of time, temperature, and atmosphere.
6. Use of high-quality atmosphere gas.

There are many combinations of ingredients available for powder metallurgy parts but the best for any specific application are those obtained through experimental work utilizing production methods.

The ingredients must blend easily and without segregation to assure uniform chemical analysis in all parts and in all areas of a single part. The alloying ingredients must diffuse readily into the powdered iron particles and the iron particles must accept them easily under the production sintering conditions. The lubricant powder in the compact must not leave residues during sintering which interfere with good bonding of the particles. Therefore the choice of ingredients can not be haphazard or by price alone, if high quality is desired.

The first basic operation, that of mixing or blending the various ingredients selected, is more critical than often realized. Even the value of the best choice of ingredients can be lost by poor blending procedures. Rather wide variations in chemical analysis, mechanical properties, and wear resistance can result even within a single part if good procedures are not followed. Careful weighing of each ingredient is an apparent necessity. Good procedures requiring careful control necessitate extra work but the uniform results obtained in actual use of parts make them very worthwhile. In the next operation, known as compacting (or briquetting), several variables again influence the production of high-quality parts. Besides a uniform blend of high-quality ingredients, high-quality tools, presses, and compacting procedures are necessary.

The tooling is quite critical and requires a very high degree of precision, if the closest tolerances possible are desired. This is especially true when relatively high tonnages are used to obtain high-density compaction. Under such pressures as 50 tons per sq in. tools can more easily fail than at the normal 15 to 25 tons per sq in .used for the production of most parts today.

Using good materials, mixing, and tooling, however, does not assure production of high-quality compacts. Press speeds must be slow enough to assure uniform filling of the powder into the cavity with every stroke of the press. Weight tolerances of 1% can be held when necessary and this is closer than usually possible with machined-steel parts. The filling hopper and shoe must be so used as to prevent any possibility of segregation of the various ingredients. Careful handling of the rather fragile compacts is necessary to prevent damage by chipping, cracking, or distorting. Proper operation of good tool designs is also necessary to prevent internal cracks caused by differential compaction.

The most important result of the compacting operation, however, is its effect on the density of a part and therefore its final strength.

Fig. 3 shows the powder compression curve for the .7C-5Cu steel. Here it can be seen that the pressure required to produce the 5.8 to 6.2 density mentioned in SAE specifications is considerably lower than that required for a density of 6.6 to 6.8.

Fig. 4 shows how much density influences the ultimate tensile strength of sintered steel. Note that a density of 5.8 to 6.2 using the .7C-5Cu steel shows an average tensile strength of about 50,000 psi, while the 6.6 density shows an average of about 75,000 psi, or a 50% gain. Since the yield strength of this material is practically the same as the tensile strength, the curve represents the usable strength when applied to gears and most other applications.

Besides high quality compacting, it is necessary to sinter the part under the right conditions with very

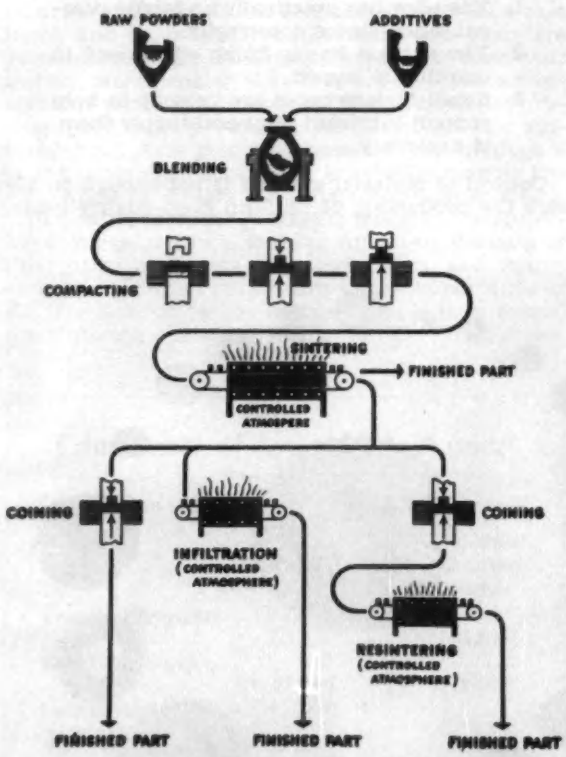


Fig. 2 — Elements of the powder metallurgy process.

close control. The tensile strength values shown in Fig. 4 are taken from standard test bars which were sintered in a production furnace under standard conditions. Sufficient temperature and time is always necessary and does influence the strength but these factors are relatively easily understood and controlled with standard methods. Probably the most important factor, however, is atmosphere control because it is difficult to understand and because carbon content has such a great influence on the mechanical properties. Fig. 4 also shows the density-tensile strength relationship of the usual low carbon, low carbon-high copper, and plain high carbon sintered steels, all of which were produced with the same basic iron powder and under identical sintering conditions. Note that the alloying of carbon and copper more than doubles the strength of the product of unalloyed iron powder as shown by the line indicating 0.1% carbon content. Copper alone or carbon alone increases the strength appreciably but a combination of the two is necessary for the best results.

Although the 0.7% combined carbon content in the .7C-5Cu steel was obtained by adding graphite to the powder mixture, this carbon content can be easily reduced to as little as 0.1% if the sintering furnace atmosphere is highly decarburizing. Because of the high temperature necessary (2000 F minimum) decarburization can be very rapid and complete. As a result, the product can be reduced in strength to that shown for 0.1% carbon and 5% copper or approximately 50% less. Also, the values can be reduced still further if the sintering temperature is allowed to drop below 1980 F which is the melting point of copper.

The value of copper as an alloy in sintered steel is largely lost if the melting point is not reached because its diffusion ratio is very slow in the solid state but very fast when molten. Therefore, even if high-quality materials are selected and compacted well, the value of this alloy can be lost completely by low-quality sintering, and its strength can be reduced by as much as 75%.

The use of high-quality atmosphere gas is important. The function of such a gas is not only to protect the compact from oxidizing at sintering temperatures but also to reduce the oxides present within the compact. Such oxides hinder the bonding action which is required for greatest strength. Therefore, it is often better to use a relatively high-cost gas, if the best strength is expected. Proper handling of even the best atmosphere gas is required, however, to assure its being satisfactory when it reaches the parts at sintering temperature. Adequate flow rates must be maintained at all times.

Besides low cost, sintered gears can have other advantages:

1. Better and more uniform finish.
2. Better and more uniform shape.
3. Less noise.

The better finish is possible because the tools can be lapped to a high degree and the parts will reflect the finish of the tools. Sintered metal is the only method which provides such quality surfaces at low cost. Better shape is often possible because various

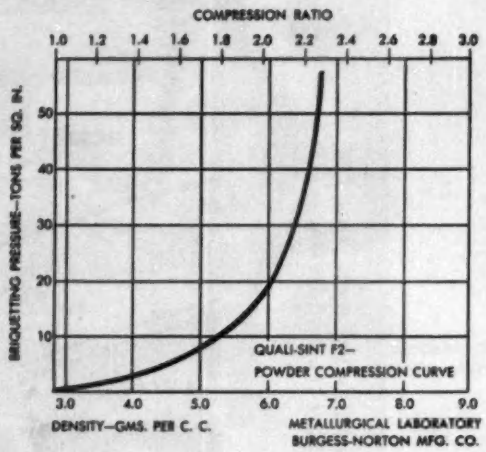


Fig. 3 — Increasing the density of a compact requires a rapidly increasing briquetting pressure.

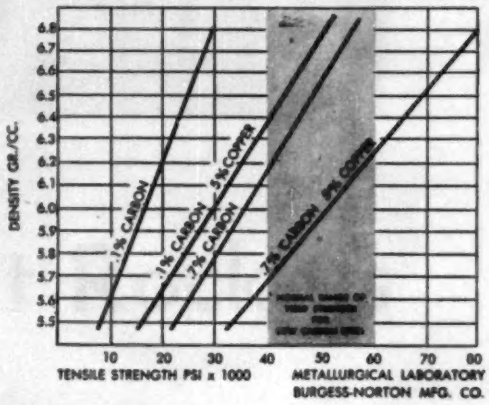


Fig. 4 — The alloying of carbon and copper produces a product of much greater strength than carbon alone or copper alone.

methods of high-speed gear production can require slightly modified tooth shapes, particularly at the root. Greater uniformity is possible because no stock removal is required and a tungsten carbide die can produce more than one million parts before wearing 0.0001 in. The lower noise level is not only possible because of the factors of better finish and shape but particularly because of the inherently low resonance of porous sintered steel, particularly when the porosity is impregnated with lubricant.

To Order Paper No. 36B
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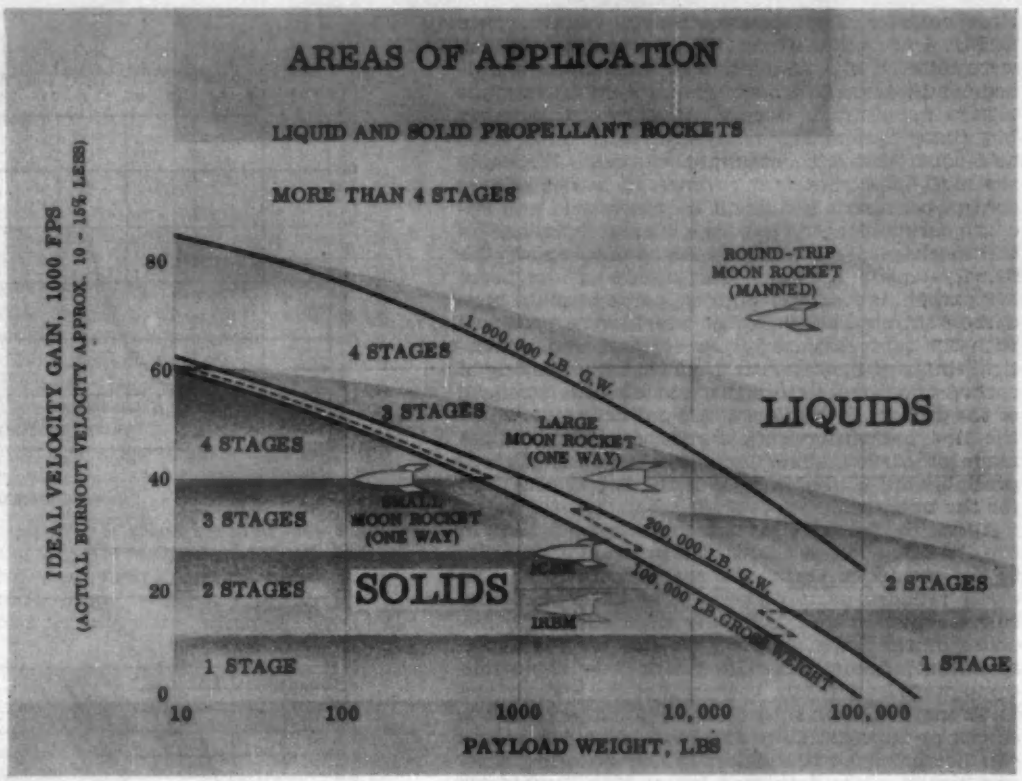


Liquid versus

Excerpts from paper by

G. S. Sutherland,

Seattle Division, Boeing Airplane Co.

NOW that we know how to make solid propellants for large rockets as well as for small ones, can large solid rockets compete with liquid units?

The answer depends on the application. Consideration of the characteristics of the two types of rockets indicate that:

Liquid-propellant rockets are superior for specialized missile applications requiring high performance or extremely large size, for satellite propulsion systems, and for boosters to escape earth or other planets for space flight.

Solid-propellant rockets are superior for small rockets for air-to-air or air-to-ground use, intermediate range ballistic missiles, intercontinental ballistic or guided missiles, and such space-flight applications as vernier rockets and retro-rockets.

Or to put it another way, for a terrestial vehicle like the ICBM, simplicity and logistic advantages make the solid propellant a logical choice. For applications demanding higher burnout velocities, the extra performance potential of the liquid rocket becomes extremely important and leads to a desirable reduction in the number of stages required, as well as a reduction in the overall bulk of the vehicle.

Some of the roles mentioned for solid rockets are new to them. Historically the solid rocket engine has been employed for applications involving small motors and short durations such as air-to-air missiles, bombardment rockets, and JATO devices. A requirement for a large rocket motor, on the other hand, has in the past resulted in almost every case in development of a liquid rocket motor. ("Large" implies here a total impulse greater than 1,000,000 lb-sec — or roughly, a total hardwear-plus-propellant weight of more than 3 tons.) The reason for the distinct separation by size was, of course, that we didn't know how to build large solid rockets.

But today large solid-propellant rockets are made

Comparison of Liquid and Solid Propellant Rockets

Point of Comparison	Liquid Rocket	Solid Rocket
Specific Impulse (Experimental 1000 psia):		
Current	263 (LOX-JP4)	Approx. 225
1960–1965	313 (F_2–N_2H_4)	Estimated 240–260
Propellant Loading Fraction:		
Current	0.92–0.94	0.85–0.92 } Estimated
1960–1965	0.96–?	0.92–0.95 }
Specific Gravity	1.01 (LOX-JP4)	1.85 (most solids)
Maximum Burning Time (1958)	No Limit	Approx. 1 minute
Practical Storage Time	Minutes (LOX, F_2)	Years (most solids)
Thrust Vector Control	Good (gimballed thrust chamber)	Under development
Thrust Termination	Good (propellant valves)	Under development
Thrust Programming	Fair (throttle propellant flow)	Limited — must be designed into motor
Environmental Limitations	As required to store or produce volatile, toxic, or corrosive liquids	Temperature control probably required during long-term storage
Special Launch-Site Facilities Required by Propulsion System	Tank farm, tank trucks, and propellant generator (LOX, F_2)	Erecting equipment
Degree of Complexity of Pre-Flight Service and Inspection	High	Low
Count-down Time on Propulsion System	Moderate — may involve top-off of volatile propellants	Very short
Propellant Utilization	Unavailable propellant due to boil-off, poor mixture control, and tank residue	Sliver loss (can eliminate by design)
Transportation	Volatile propellants require special equipment	Large rockets require special equipment. Ultimate size limit
Reliability (1958–1960)	Good (80–99%)	Excellent (95–99.9%)
Costs		
Development	5	1
Production	1	1

Solid Propellant Rockets

by a casting process. That is, the propellant consists in part of organic polymers which are initially in the liquid state and, when heated to a suitable temperature or exposed to catalysts, polymerize to tough, rubbery solids. Consequently the rocket is prepared as a liquid or slurry, and poured into the rocket case to solidify.

Here's how liquid and solid rockets compare on the basis of performance, reliability, logistics, and costs:

Performance

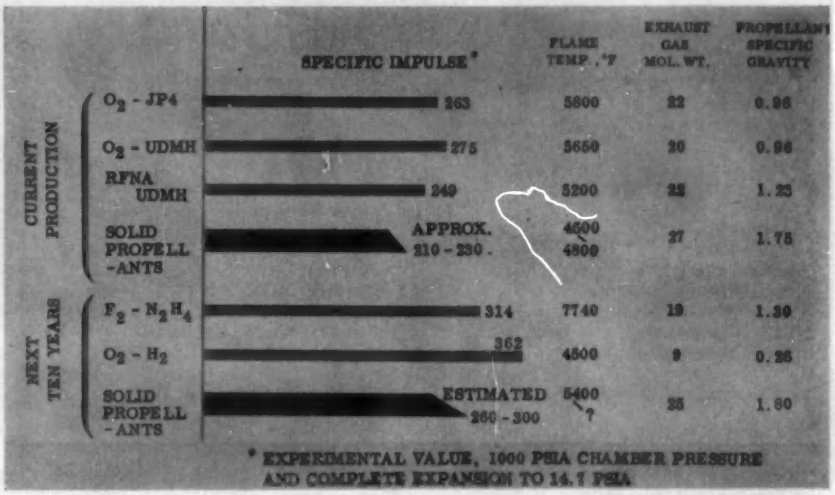
The two most important performance parameters with which rocket designers are concerned are specific thrust and propellant loading fraction.

Specific Impulse — Comparison of the specific impulse of several important liquid propellants with some solid propellant formulations shows that while the solids have poorer specific impulse values, they are considerably more dense.

Plotting the same data on a time scale makes it obvious that, while solid propellants are not likely to match the best liquid combinations in the foreseeable future, the gap in performance has been narrowed considerably over the last 10 years. The LOX-JP4 system is by far the most popular liquid propellant system in use today, primarily because the low cost of the propellants is coupled with good performance and a 10-year backlog of experience. Fluorine systems will be developed, but due to the higher cost, toxic exhaust, and limited raw material reserves, they may never be used for purposes other than those demanding high performance. Liquid oxygen-hydrogen systems will also be used in the future for specialized applications demanding maximum specific impulse.

Propellant Loading Fraction — A fundamental difference between the liquid and solid rocket motors is that in the case of the liquid rocket, the propellants are stored at a relatively low pressure (like 50 psia) and then pumped into the combustion

Specific impulse of selected liquid and solid propellants



Liquid versus Solid Propellant Rockets

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chamber at an elevated pressure (perhaps 500 psia); while in the solid unit, the tank and combustion chamber are one and the same and must be designed to withstand the full combustion pressure. This fact immediately gives the liquid system an advantage, and the solid rocket designers have been hard-pressed to improve the propellant loading fraction of their designs to the point where the solid is competitive with the liquid. An advantage in this regard that the solids possess is that they are considerably denser than most liquid propellants.

Typical construction of liquid propellant tanks may involve a thin skin covering longitudinal integral stiffeners with circumferential frames, or possibly a tank made from a single sheet of aluminum or steel which maintains its form by utilizing a positive internal pressure. The rocket engine assembly is attached to the tank section by members that transfer the thrust to the tank walls. For large liquid rockets, tank skin thicknesses may be as low as 0.020 to 0.100 in., and this lightweight construction results in very high propellant loading fractions.

Solid propellant rockets, on the other hand, are forced to employ somewhat heavier construction. The cylindrical portion of the motor may be constructed of a high-strength steel (SAE 4130) that has been welded and heat treated. The fore and aft closures may be machined forgings with suitable provisions for attachment of the case and the nozzles.

Due to the difficulty of constructing and heat-treating large pressure vessels such as solid rocket motor cases with diameters approaching 8 ft, alternative methods of construction are being developed. These newer techniques involve the use of very high tensile strength steels or reinforced plastics. Reinforced plastic cases offer some advantages in tooling and production techniques, as well as possible weight savings.

In order to resist the intense heat and erosion, the uncooled nozzle on the solid propellant rocket has of necessity been relatively heavy. Effort is currently directed toward finding suitable ceramic or other refractory coatings which will allow a considerable reduction in nozzle weight.

Analysis of trends in propellant loading fraction, special impulse and burnout velocity shows that by 1960, rocket technology will have reached the point where it will be possible to build solid or liquid one-

Questions and answers on Solid

as reported by the secretary of the session **Charles J. Wilde**
Reaction Motors, Inc.

Q. Does the structural efficiency of a rocket engine reach asymptotic value with increasing size?

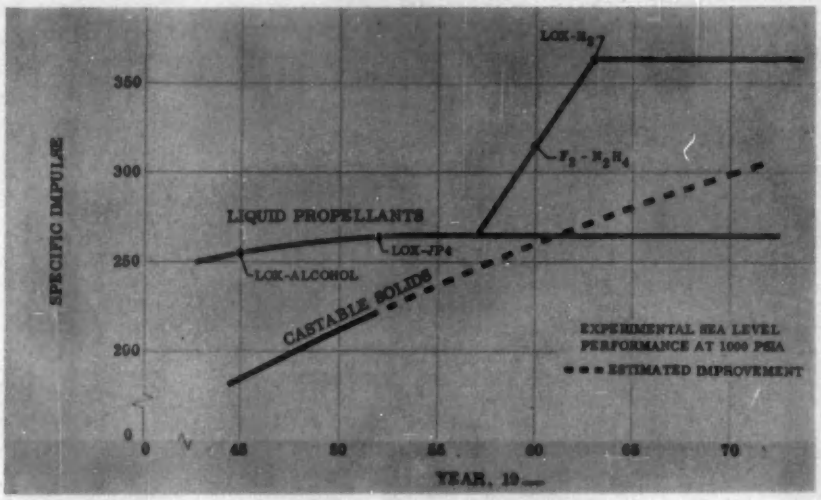
A. There is certainly a limit, but generalized definition is not possible because this limit depends upon specific design details.

Q. Do you think there is hope or any point to recovering the case of solid rocket engines?

A. Yes there is — as rockets get larger and the dollar value of the case makes it worthwhile. Any recovery techniques however, would have to be exceptionally good to prevent damage to the case. This is necessary since most solid rocket cases are highly stressed, and large solid rocket cases are relatively fragile when empty.

Q. Would better propellants improve the packaged liquid propellant picture?

A. The packaged liquid powerplants will undoubt-



Specific impulse improvement curves for solid and liquid propellants

stage IRBM's and two-stage ICBM's, as well as three-stage moon rockets.

Control — The quantities that require control with liquid and solid rockets are the thrust vector and thrust duration, and, occasionally, thrust level. Thrust vector control is required during powered flight to correct deviations from the desired flight path. Thrust duration control is necessary to insure that the burnout velocity of the rocket falls within the tolerance limits allowed by the target requirement.

Thrust vector control is accomplished quite neatly in the case of the liquid rocket motor by mounting the combustion chamber-nozzle assembly on a gimbal. Actuators position the motor to give the correct magnitude and direction of side force in response to signals from the control system.

A similar device is impractical in the case of the solid-propellant rocket motor. Systems suited for use with solid propellant rockets include jet vanes and jetevators. The fundamental difference between the two systems is that the jetevator is only exposed to the hot gases when a control force is needed. This is a decided advantage from the ma-

versus Liquid Propellant Rockets

edly show improvement as new propellants become available.

Q. Is there any limit to the size of solid propellant rockets?

A. For the purpose of this paper we have set an arbitrary limit of 100,000 lb selected for the convenience in ground handling. Solid propellant clusters which can be assembled on the ground would increase total size.

Q. Is there any reason why solid rocket engines cannot be loaded in the field?

A. No. However, the problems of shipping, loading, and quality control would be difficult. Pouring without voids and curing is a complicated process.

Q. Is it possible to combine solid and liquid engines?

A. Yes. However, for simplicity and clarity the paper did not or could not attempt to encompass all combinations.

Q. Do you have any information on reliability versus size for liquid rocket engines?

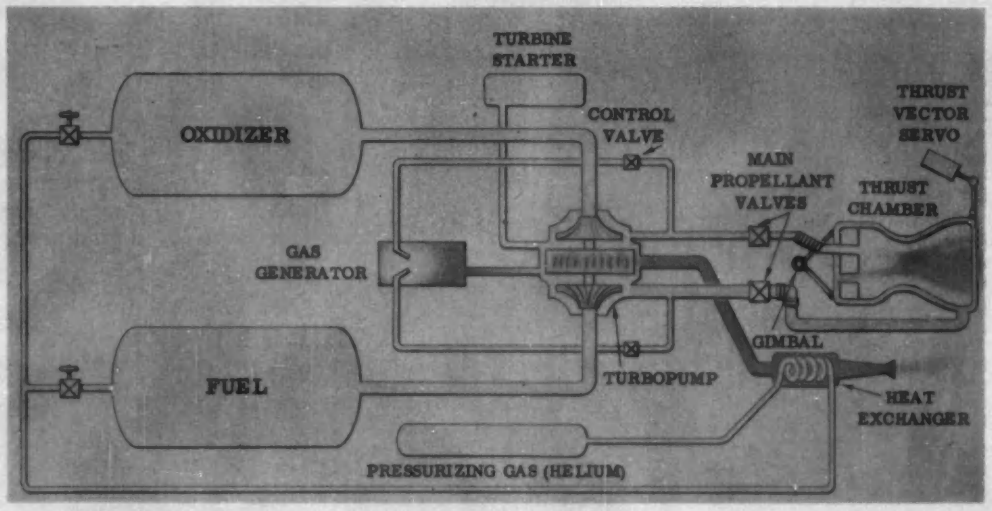
A. No. However, it is natural to assume the reliability will improve as a function of time and experience. We have been building large liquid rockets for only a short time, and I believe that the near future will bring surprising improvements in liquid rocket reliability.

Q. Is there any future for monopropellant fuels which would improve liquid engine reliability?

A. Yes, though not immediately.

Q. How do you justify your production cost comparisons between liquid and solid engines, which indicate very little difference?

A. The extreme quality control requirements for the solid-propellant rocket engines essentially offset the higher costs of the liquid rocket inert parts.



IN THE LIQUID-PROPELLANT ROCKET the propellant tanks are pressurized prior to ignition to a relatively low pressure (say, 50 psia) by an inert gas. The turbopump is energized by the turbine starter, and, when the main propellant valves are opened, a reduced flow of propellants enters the chamber. The burning igniter squib causes propellant ignition, after which full propellant flow is allowed to enter the chamber. During this initial period, propellants are flowing to the gas generator, burning, and producing hot gases to drive the turbopump. As soon as the turbopump comes up to design speed, full-scale operation of the motor begins.

The exhaust gases from the turbine are ducted around a heat exchanger through which passes the gas (usually helium) used to pressurize the propellant tanks. The fuel is circulated through the walls of the nozzle and combustion chamber for cooling purposes prior to injection. A small fraction of the propellants is diverted to the gas generator after passing through the turbopump. A gimballed nozzle for thrus vector control is shown.

Liquid versus Solid Propellant Rockets

. . . continued

terial standpoint. In addition, thrust losses due to the drag of the jetevator will be smaller. On the other hand jet vanes are more effective, and possibly lighter in weight than an equivalent jetevator.

A movable exhaust nozzle is an alternate control method, and appears to be the most attractive scheme provided that an effective seal at the joint can be developed.

Thrust termination is accomplished in the liquid rocket engine by simply closing the main propellant valves upon command. The thrust of the solid rocket is somewhat harder to turn off, but there are several techniques that can be employed. One method involves blowing off the exhaust nozzle, in order that the resulting reduced pressure in the chamber will cause the fire to go out. This method will not work with some propellants, and there also may be undesirably large longitudinal accelerations associated with the transient flow that develops after the nozzle is removed.

Another scheme involves opening forward-facing exhaust ports or nozzles upon command and producing a reverse thrust that effectively cancels the forward thrust. It is rather early to say if this scheme will be successful in those cases demanding extremely careful control of the burnout velocity.

A third method requires the discovery of a substance which, when injected into the motor in small quantities, will extinguish the solid propellant flame.

Thrust lever control may be accomplished in the liquid rocket motor by throttling the flow of propellants to the rocket chamber or by control of the turbo pump speed. This may be done during flight upon command, whereas in the case of solid rocket motors, thrust level variations can be designed into the propellant grain by suitable pre-selected changes of the burning surface area, but thrust cannot be varied from this original program after the motor is fired.

Another control system that is unique to the liquid rocket motor is the propellant flow control system designed to adjust the propellant mixture ratio to insure that both fuel and oxidizer are consumed simultaneously at burnout.

Combustion Instability — Combustion instability has in the past been more of a problem with liquid rockets than with solids. This may well be attributed to the fact that the processes of injection, droplet breakup, vaporization, and mixing are more important in the case of liquid propellants than with solids, which are, in a sense, premixed and preinjected.

Combustion instability in solid rockets, when it occurs, can be cured by the addition of a few percent by weight of any of several compounds, whereas curing combustion instability in liquid rockets can involve a costly trial-and-error experimental program. Fortunately, sufficient experience has been accumulated in dealing with liquid propellant in-

stability to enable the designer to eliminate most of the common sources of instability.

Thrust Duration — The uncooled nozzle of the solid propellant rocket requires the thrust duration of high performance solid rockets to be restricted to periods less than about 1 min. Work is in progress to extend this limit, but it is unlikely that solid rockets will ever be able to match the almost unlimited durations of the regeneratively cooled liquid rocket motor.

These short durations mean that the solid rocket will have higher thrust/weight ratios and accelerations than its liquid-propellant counterpart. High thrust/weight ratios are beneficial in that burnout velocity loss due to gravity decreases as thrust/weight ratio increases, but problems of aerodynamic drag and heating increase directly with thrust/weight ratio. High accelerations may also have an adverse effect on guidance and communication equipment.

Temperature Sensitivity — A problem that is uniquely associated with solid propellants is temperature sensitivity. Temperature-sensitive solid propellants have a burning rate which is a function of the initial temperature of the propellant prior to ignition. For example, most solid propellants have burning rates which increase by about 0.05 to 0.2% per degree Fahrenheit increase in initial temperature. This phenomenon results in an undesirable dependence of the performance on the storage temperature of the rocket. Work is in progress to develop propellants which exhibit little or no temperature sensitivity.

Simplicity and Reliability

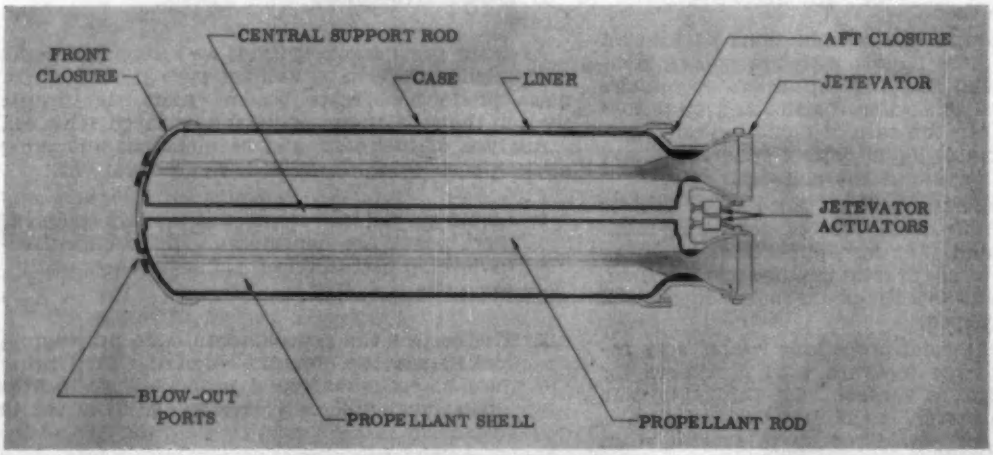
In Table 1 we have listed the working or moving parts and sub-systems of typical liquid- and solid-propellant rocket motors.

Table 1 — Complexity Comparison

	Solid Rocket	Liquid Rocket
Major Sub-Systems		
Preflight Checkout	No	Yes
Ignition	Yes	Yes
Starting Sequence	No	Yes
Propellant Utilization	No	Yes
Gas Generator	No	Yes
Tank Pressurization	No	Yes
Thrust Vector Control	Yes	Yes
Thrust Termination	Yes	Yes
Thrust Level Control	No	Yes
Number of Working Parts		
Valves	0	45
Regulators	0	4
Filters	0	6
Solenoids	0	14
Switches	0	13
Other	2	16
Total	2	98

In liquid rockets, the primary reliability problems arise in the metering and flow control of the propellants. In addition, there are additional failure hazards due to certain inherent characteristics of the system. Examples of these are failures due to combustion instability, explosive starts, and propellant sloshing. These types of failures may be eliminated early in the game by design improvements.

The principal sources of failure in the solid rocket are grain cracks, insulation failure leading to case or nozzle burnout, and ignition malfunction. In



IN A TYPICAL SOLID PROPELLANT ROCKET the solid propellant consists of two parts, a central rod and an outer shell. The outer shell is bonded to the metal case with a special adhesive to prevent hot gases from penetrating the junction between the case and propellant. The central propellant rod is supported at the fore and aft ends of the motor and usually has a central support running the length of the propellant. Burning occurs on the surface of the annulus, and the surface recedes radially outward and inward. By utilizating the propellant to protect most of the combustion chamber walls during the burning period, light-weight, efficient case designs can be achieved.

Blow-out ports at the head end are shown. These are for the purpose of neutralizing the thrust to obtain precise control of the burnout velocity. Thrust vector control devices, known as jetevators, are shown on the nozzles.

Liquid versus Solid Propellant Rockets

. . . continued

this regard an outstanding problem with solid-propellant rockets today is developing an efficient crack detector.

Without delving into the mathematics of probability, we intuitively feel that the liquid system, with its large number of working parts, many of which are arranged in series, will have the poorer reliability.

Also important is the fact that liquid-propellant systems, due to their greater complexity, require more sophisticated preflight inspection, fueling, and checkout equipment. The reliability of the servicing and inspection equipment would be an important factor affecting successful operation under adverse conditions.

Logistics

Transportation — The liquid rocket motor and tanks are transported from the factory to the firing site. At the launching site, the vehicle is erected and loaded with propellants. Solid-propellant rockets, on the other hand, are loaded with propellant at the factory, and then carried to the launching site.

This difference in the place at which the propellants are added can become very important for very large rockets. It is estimated that solid-propellant rockets weighing 80,000 to 100,000 lb are close to the upper limit of convenient handling and roadability. Consequently, very large solid rockets must be shipped in parts and assembled at the site (a technique not yet developed), or clusters of smaller rockets must be used.

Most liquid propellant combinations of interest involve one or more liquids with low boiling temperatures. Special shipping containers or vehicles must be provided to eliminate losses and/or release of toxic fumes. In the case of liquid oxygen, however, special portable liquid-oxygen generators have been developed for use at the launching site.

It appears, therefore, that there is a definite upper limit to the useful size of solid-propellant rocket motors, and that for applications requiring extremely high values of total impulse (greater than about 50,000,000 lb-sec) the liquid rocket engine will probably be employed.

Handling — The solid-propellant rocket may require special storage facilities with provisions for ambient temperature control. On the other side of the ledger, however, is the fact that solid units may be stored for periods of up to several years with no deterioration provided reasonable ambient temperatures are maintained. Also, special launch-site liquid-propellant equipment such as propellant generators, tank trucks, fueling facilities, and propellant storage equipment plus the trained operators required for such equipment are not needed in the case of the solid-propellant motor.

Launching — In this category, our comparison rests upon the assumption that the solid and liquid rockets are being used to propel an offensive or defensive weapon system. For scientific purposes, or space travel, some of the arguments listed below lose their significance.

Short reaction times are important in most weapon systems. For an offensive assignment, the system will probably operate under an "immediate" retaliation policy. In fact, it is desirable to have the weapon launched soon enough after an alert to escape destruction by an incoming enemy weapon. On defense, instant readiness is of course mandatory.

Solid-propellant rockets are inherently suited to applications requiring very short count-down times. There are certain storable liquid propellant combinations which can approach the solid in the time category. For example, systems based on red fuming nitric acid or hydrogen peroxide fall in this category. These liquid systems require rather careful handling procedures. In addition, the performance of the currently available storable liquid propellants is less than that of soon-to-be available solids. Hence it does not appear that storable liquids will find wide application in future weapon systems. However, for applications where thrust level control, repeated starting and stopping, and reusability of the motor and tanks are important (for example, aircraft JATO and manned rocket planes), the storable liquids appear attractive.

Before firing, the propulsion system must be checked out. Except for the ignition system, the solid rocket requires no checkout, whereas certain valves, regulators, and solenoids in the liquid rocket must be shown to be in working order prior to launch. Consequently, should the tactical situation require rapid shifting of launching sites, the solid unit, with its smaller amount of support equipment and short count-down times, should prove more adaptable than a system utilizing a liquid rocket.

Costs

As in the previous category, if we assume that our comparison concerns a weapon system subject to mass production, costs become more significant than in the case of one-of-a-kind research vehicles.

Analysis of fuel costs and development and production costs leads to the following conclusions:

1. Liquid propellant rockets, due to more complex inert parts, are considerably more expensive to develop than solid propellant rockets of the same size.

2. The cost of the propellant in solid propellant rockets may be almost 50% of the total production cost, but liquid propellant costs are almost negligible compared to the inert parts costs.

3. Production costs of comparable solid and liquid rocket motors are approximately equal.

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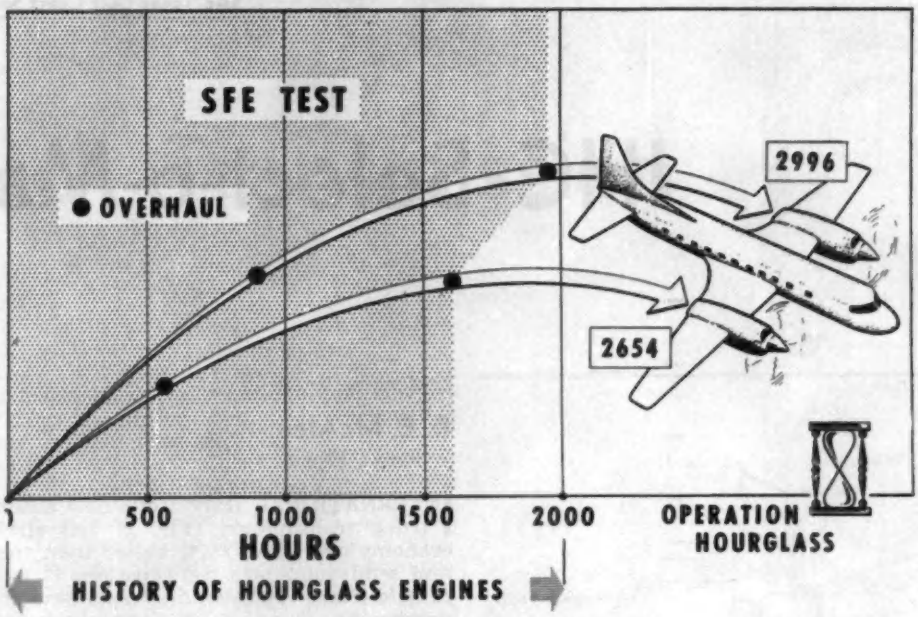

Fig. 1 — Allison 501-D13 propjet engine overhaul history prior to installation for 1000-hr flight test. Maintenance time for both engines during test was 215 man-hr.

Allison 501-D13 Turboprops . . .

. . . complete 1000 hr of simulated airline service without overhaul. Utilization averages 12 hr per day.

Based on paper by

Fred H. Steuber

Allison Division, General Motors Corp.

A VIGOROUS flight test program for its 501-D13 propjet engine was launched by Allison in the fall of 1957. The objective of Operation Hourglass, as the test was called, was to complete 1000 hr of flight patterned after airline schedules. To this end, a YC-131C aircraft was leased from the Air Force and outfitted with overhauled engines which already had seen 1600 and 1958 hr of operation upon installation (Fig. 1).

Operation Hourglass began Nov. 1, 1957 and by Jan. 23, 1958, the flight of 1000 hr had been completed. The aircraft flew every day except Thanksgiving and Christmas and one other day when it was grounded because of hydraulic trouble. Neither of its engines or propellers was removed and the average utilization was 12 hr per day. The oil consumption was less than 10 gal per engine for the 1000 hr of operation, or 0.0095 gal per hr per engine. The total maintenance time required for both engines was 215 man-hr.

Airline personnel had estimated a standard Convair 340 would require 12 sets of tires for 1000 hr of flight, but tires were changed only once, at approximately 600 hr and then merely as a precautionary measure. This long tire life is attributed to using the reverse thrust of the engines rather than the aircraft brakes for braking. Thus, brakes as well as tires were conserved.

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. . . on which this article is based, turn to page 5.

Abridgment of an

SAE Texas Gulf Coast Section Paper

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R. E. McAfee

International Harvester Co.

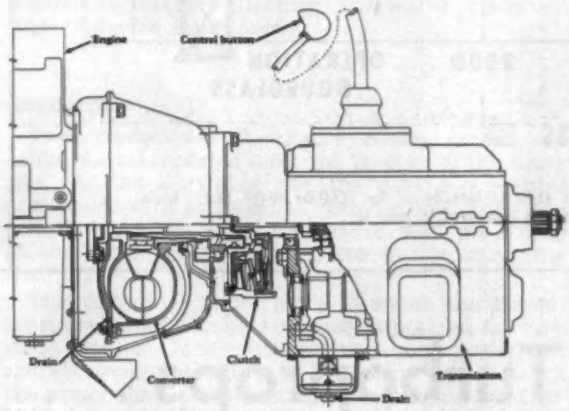

Fig. 1 — IHC Select-o-Matic transmission employs a torque converter in the drive line. An automatic type transmission, it differs from torque converter equipped fully automatic transmissions in both gearbox and controls.

INTERNATIONAL Harvester's new automatic-type truck transmission (Fig. 1) has shown a fuel economy averaging 2¾% better than the standard and semi-automatic transmissions it has replaced in field trials. Maintenance costs have shown a reduction by virtue of the torque converter in the drive line, which dampens shock loads on the power train, eliminates engine lugging, and ends excessive clutch wear.

It is in the gearbox and in the controls that the Select-o-Matic transmission differs from the so-called fully automatic transmission employing a torque converter. The gearbox is a 3-, 4-, or 5-speed, synchronized, countershaft type with an electrically controlled, hydraulically actuated clutch. The clutch interrupts the transmission of torque during shifting. Shifting is not done under power. All gear ratios are manually selected so that positive control of a desired gear ratio is maintained at all times. The transmission is "locked" in the selected ratio range and will not shift from this range automatically. The positive control permits a higher ratio (third or fourth) to be selected for

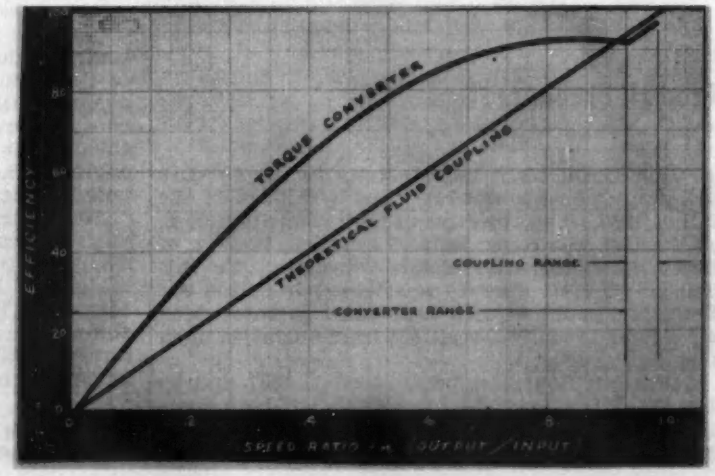

Fig. 2 — Peak converter efficiency of 92.6% and peak coupling efficiency of 97% contribute greatly to transmission's economy and obviate need for lockup clutch.

Truck Transmission

starting to insure maximum traction under slippery road conditions and prevent automatic shifts which might cause the vehicle to skid.

Torque Converter Efficiency

The peak converter efficiency is 92.6%, as shown in Fig. 2. The peak coupling efficiency is 97%. This high efficiency explains in part the economy of the transmission. It is also one of the reasons for omitting a lockup clutch in the design. Fig. 3 shows a cross-section of the converter. If the converter were inefficient there would be merit in using a lockup clutch to improve efficiency in the cruising range. However, such a clutch eliminates the shock damping characteristics of the converter, which is undesirable, and it also adds to design complexity and cost.

Variables Affecting Performance

Performance is dependent on the compatibility of the entire driveline as well as the power to weight ratio of the vehicle. The compatibility of the engine-transmission combination and the shape of the engine torque curve definitely influence the size of the transmission gear step and the power available for propelling the vehicle.

The size of the gear steps required to cover the torque range and the resulting drop in power between shifts are measures of compatibility. Power drop is the difference between the horsepower at maximum engine speed and the horsepower at the engine speed just prior to the downshift.

The most convenient method for determining the size of the gear steps, and the resulting drop in power between shifts is to plot the engine torque curve on log-log coordinates. Constant horsepower curves will be straight lines at a 45-deg slope and simple logarithmic scales can be laid off on the graph for gear steps and for per cent of maximum power.

Determination of Desirable Power Drop

A comparison of three theoretical engines is shown in Fig. 4. Engine No. 1 has a falling torque curve; engine No. 2 has a constant torque curve, while engine No. 3 has a rising torque curve. All engines have the same top speed (4000 rpm) and identical maximum horsepower.

First, assume each engine has a transmission with

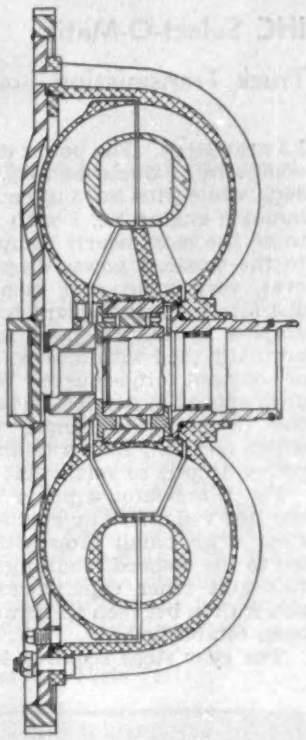

Fig. 3 — Cross-section of IHC converter in new automatic-type truck transmission.

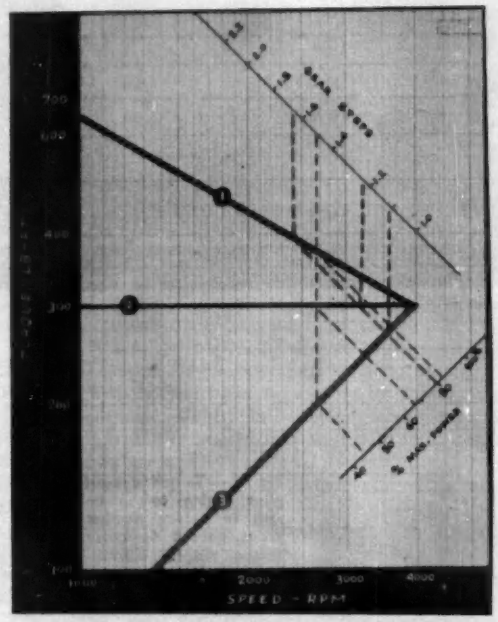

Fig. 4 — Comparison of three theoretical engines, all with top speed of 4000 rpm and identical maximum horsepower, but having falling, constant, and rising torque curves, respectively. Transmission in each case has 1.5 gear steps. Engine No. 1 with falling torque curve is shown to have the most nearly compatible engine-transmission combination because of smallest power drop between shifts.

IHC Select-O-Matic Truck Transmission (continued)

1.5 gear steps. The power drop between shifts with engine No. 1 would be 16%, with No. 2 it would be 34%, while with No. 3 it would be 56%. This would indicate engine No. 1 with a 1.5 step transmission to be the most nearly compatible combination due to the smallest power drop between shifts. However, very small gear steps can result in power changes too insignificant to be useful. This is exampled by the 10-speed roadranger transmission normally used with diesels, which have a fairly flat or constant torque curve. With 1.3 steps, the power drop approximates 20% between shifts. But couple the 10-speed roadranger with gasoline engines, which normally have a falling torque curve, and the power drop is so small that drivers skip-shift.

Fig. 5 indicates a power drop of only 6% when the IHC V-8 549 cu in. engine has a 1.3 transmission step. This small drop with gasoline engines has led to the 8-speed roadranger with 1.4 steps. From this and other experiences the desirability of a power drop between shifts averaging about 20% has been established.

The gear steps required to limit the power drop to the desirable 20% are shown in Fig. 4. Engine No. 1 should be coupled with a transmission having approximately 1.65 steps; No. 2 a transmission with approximately 1.25 steps, while engine No. 3 needs a transmission with about 1.1 steps. This indicates that engine No. 1 would require fewer gear ratios than the other engines. Experience proves most transmission applications need a low gear ratio of approximately 7.5, therefore the transmission with engine No. 1 (1.65 steps) would require five ratios to cover the entire range; engine No. 2 (1.25 steps) would require 10 ratios, and No. 3 (1.1 steps) would need 20 ratios.

Converter Reduces Number of Gear Ratios

The effects of a torque converter on an engine torque curve shape are shown in Fig. 6. Curve 1 is the basic engine torque. Curve 2 is the torque of an engine-converter combination using the same basic engine. The torque converter multiplies engine torque below 2000 rpm so that the resultant curve approaches more closely the falling torque curve. Obviously, this would reduce the number of transmission gear ratios required to cover a given torque range.

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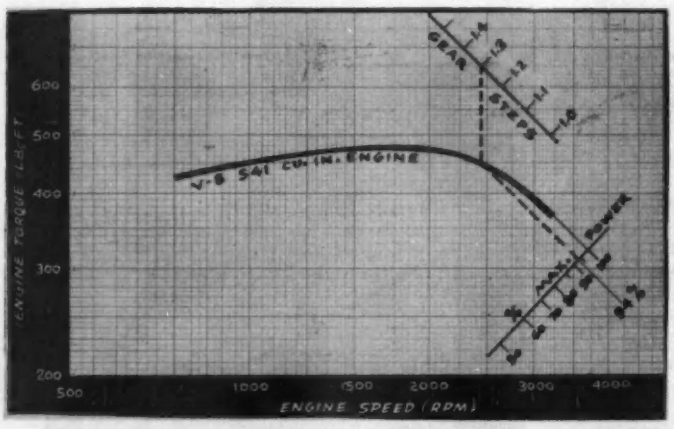

Fig. 5 — IHC V-8 549 cu in. engine with 1.3 transmission step has a power drop of only 6%. Experience shows most desirable power drop between shifts to be about 20%.

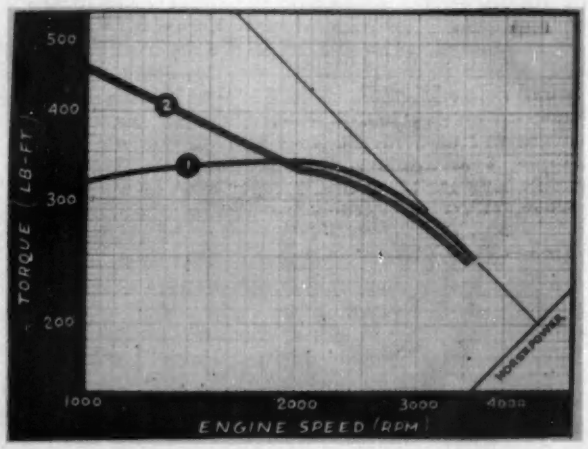

Fig. 6 — Torque converter multiplies engine torque below 2000 rpm to reduce number of gear ratios needed to cover a given torque range. Curve 1 is the basic engine torque while curve 2 is the torque when a converter is added.

Jet-Driven Lifting Rotor . . .

. . . is a logical method of giving an airplane VTOL capability that has not yet received the consideration it deserves.

By

Kurt H. Hohenemser

McDonnell Aircraft Co.

THE most logical method of obtaining VTOL capability of a plane — the addition of a jet-driven lifting rotor — has attracted little attention so far. Yet this method has many decisive advantages over others that have received wider consideration. There is no "conversion" problem like that for the tilt-wing or tilt-rotor types. There is no excessive downwash in hovering like that for tilt-wing propeller or ducted fan types. There is no necessity for excessive and uneconomic power to gross weight ratios like those for the propeller, ducted fan, or jet VTOL planes.

Performance Is Sacrificed, Compared to Airplane

Any method of incorporating VTOL capability in an airplane leads to considerable performance penalties. For many VTOL planes it appears questionable if, after development through the flight test stage, there still will be a useful load to empty weight ratio left that has any economic significance. In the case of the jet-driven lifting rotor as the means of obtaining airplane VTOL capability these penalties are partly compensated by large savings in airplane component weights, since wing and propellers do not have to be designed for running take-offs or landings or for slow-speed flight. While conventional airplanes have wing plus propeller weights of about 15% of gross weight, these items can be reduced to 5% for the VTOL airplane with single lifting rotor. The added components amount to 20% of gross weight, leaving a reduction in useful load of 10% of gross weight.

Performance is Gained, Compared to Helicopter

When we compare the VTOL plane with jet-driven lifting rotor with the gear-driven helicopter, it is found that the added weight from the wing and propellers including their drive and the added downwash load on the wing in hovering (wing tips folded) is approximately compensated by (1) the savings in weight from the much lighter rotor jet drive and (2) from the elimination of torque compensation. Therefore, the useful load to empty weight ratio is about the same as that for a comparable helicopter.

The main disadvantage of the jet-driven helicopter — its high fuel consumption — is of no significance for the VTOL airplane since rotor drive is used only for a short time during vertical take-off and landing.

In cruising, the lifting rotor is autorotating rather than power-driven and carries not more than a fraction of the total aircraft weight. The overall lift-to-drag ratio of the craft, including wing, rotor, fuselage, and the like, is in the order of 10/1 — at least twice as good as that for present-day helicopters. The lightly loaded autorotating rotor can be operated at far higher flight speeds than those obtainable in helicopters without encountering the well-known limitations from blade stall, from high blade tip Mach number or from excessive loads and vibrations. The widening of these limits, together with the greatly improved lift-to-drag ratio, gives the VTOL airplane about twice the cruising speed (and twice the cruising economy) of the helicopter of the same size and the same installed power.

Main Conclusions from Flight Tests

The first VTOL airplane with jet-driven lifting rotor was the McDonnell XV-1, sponsored by the U. S. Army and administered by the Air Force. Flight testing began in July 1954 and went through the Air Force Phase II Evaluation in the spring of 1956. Recently, a much larger craft of this type, the Fairey Rotodyne in England, began flight tests. Here the rotor is unloaded in cruising flight to one-half of the gross weight, while the XV-1 rotor is unloaded in cruising to one-sixth of the gross weight, which gives it a higher speed potential. The main conclusions from the XV-1 flight tests are the following:

1. The rotor system especially developed for the XV-1 combines inherent stability in helicopter flight with smooth, vibration-free autorotation at half helicopter rpm in airplane flight. The presence of the slowly autorotating rotor is hardly noticeable in airplane flight and has no detrimental effects on airplane stability and control.

2. The automatic rotor speed control developed for the XV-1 keeps the rotor rpm in airplane flight almost constant, independent of gusts or maneuvers.

3. The transition from helicopter flight to airplane flight (and vice versa) is made in three easy steps:

(a) Power transition from rotor drive to propeller drive.

(b) Control transition (disconnect of longitudinal rotor control from stick).

(c) Deceleration of rotor and engagement of automatic rotor speed control.

4. The noise from the blade tip jets during vertical take-off and landing is strongly attenuated with distance and several hundred yards away from the craft the noise level of improved tip burners was found to be lower than that produced at the same distance by a gear-driven helicopter with reciprocating engine.

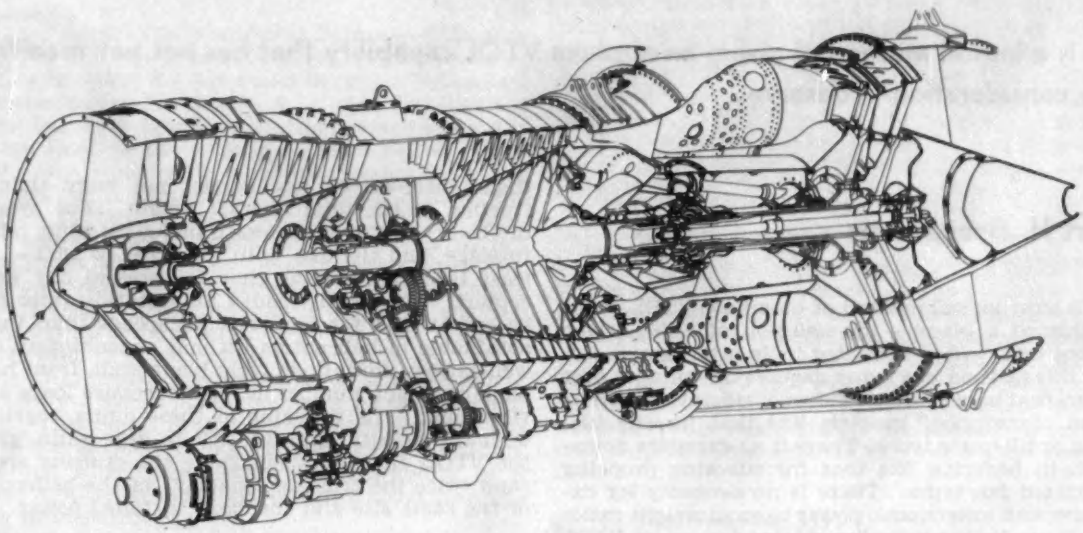

Fig. 1 — Cut-out view of the Wright TJ38 low-temperature, low-pressure-ratio turbojet developed from British Olympus engine.

• *Features of the low-temperature, low-pressure-ratio*

TJ38 Zephyr Commercial

Based on paper by

Leonard Green and Bruce Gordon

Wright Aeronautical Division, Curtiss-Wright Corp.

THE TJ38 is a simple, low-temperature, low-pressure-ratio turbojet for commercial transports. It represents a redesign of the Olympus engine by Wright Aeronautical in collaboration with Bristol Aero Engines (Fig. 1).

As a starting point, the cycle requirement was refined and the engine rematched for a sea-level static design point of 230 lb-sec at a pressure ratio of 10/1. This engine provided 12,500 lb of thrust for sea-level static take-off at a turbine inlet temperature of 1340 F, thus giving adequate temperature and rpm margin for constant thrust under hot-day and/or limited-altitude conditions. Cycle calculations at cruise altitude showed a maximum cruise thrust of 3600 lb at a pressure ratio of 10.5/1 with a turbine inlet temperature of 1160 F. Normal cruise is 3000 lb of thrust at a pressure ratio of 9.5/1 with a turbine temperature of 1050 F. Checking these cruise points on generalized altitude cycle curves (Fig. 2) shows near optimum sfc.

Drag Considerations

Use of a compressor with a high airflow per unit frontal area provides the required airflow within an engine diameter of 41 in. If a high-temperature, high-specific-thrust design (of say 66 lb-sec) had been selected to produce the take-off thrust, with the same airflow per unit frontal area, the engine diameter could have been reduced to approximately 38 in. The difference in resultant nacelle drag with these two engines is only 15 lb per nacelle at cruise conditions, or less than 0.5% in terms of fuel consumption.

Feature of Constant Power

With an engine designed to operate at low turbine inlet temperatures it is logical to use some of the

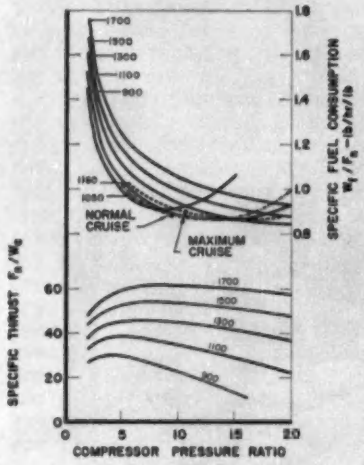

Fig. 2 — Cruise points on generalized altitude cycle curves show TJ38 to have near optimum specific fuel consumption (35,000 ft, 475 knots).

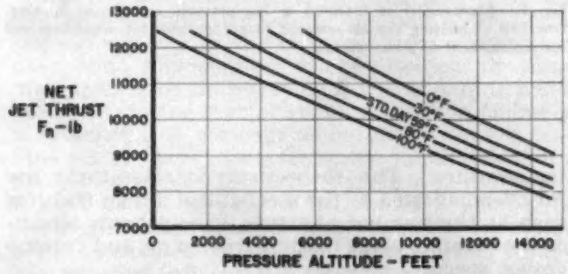

Fig. 3 — Turbine inlet temperature for take-off thrust under hot-day conditions is 1485 F. On standard day the take-off thrust can be maintained up to 2700 ft altitude (0 knots).

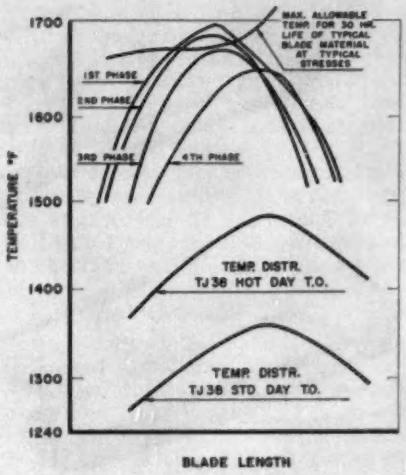
TEMPERATURE °F
BLADE LENGTH
MAX. ALLOWABLE TEMP. FOR 30 HR. LIFE OF TYPICAL BLADE MATERIAL AT TYPICAL STRESSES
1ST PHASE
2ND PHASE
3RD PHASE
4TH PHASE
TEMP. DISTR. TJ38 HOT DAY T.O.
TEMP. DISTR. TJ38 STD DAY T.O.

Fig. 4 — Low turbine inlet temperatures are easy on materials, hence blade problems are reduced to a minimum or rendered negligible.

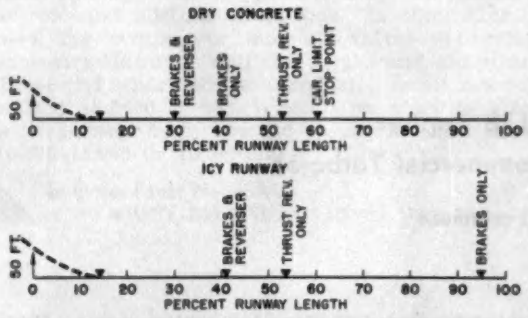

Fig. 5 — Effect of thrust reverser as a means of supplementing aircraft braking during landing roll (8900-ft runway).

Turbojet

built-in temperature margin to maintain the engine thrust at standard values for high ambient conditions. The simplest way to increase turbine inlet temperature is to open the throttle which, with a fixed area nozzle, will increase rpm and airflow. This is the approach used on the TJ38 (Fig. 3). The turbine inlet temperature required to maintain take-off thrust under hot-day conditions is 1485 F, which is still well below the standard-day operating temperatures of the conventional jet engine. Moreover, take-off thrust can be maintained up to 2700 ft altitude on a standard day.

Problem of Noise

The noise level of the unsuppressed high-temperature, high-powered jet is from 9 to 22 db higher than that of the reciprocating engine powering transports — and it constitutes a major problem. The main source of this noise is the exhaust jet stream, arising mostly from the turbulent mixing of the exhaust jet with the surrounding atmosphere. It is generally accepted that the noise power generated by the exhaust jet stream varies approximately as the eighth power of the jet velocity, hence a large reduction in noise can be made by a relatively small reduction in jet velocity.

The TJ38 requires much less suppression than the high-temperature turbojet because of its inherent quietness. A simplified suppressor nozzle having minimum loss characteristics has brought the noise down to a level comparable to that of the current transports. The basic quietness of the engine, coupled with this nozzle, results in a negligible performance loss. The nozzle is furnished with the engine, hence all performance ratings given here include the effect of the suppressor.

Reliability

A primary advantage of the low turbine temperature cycle is the increased durability and life of the

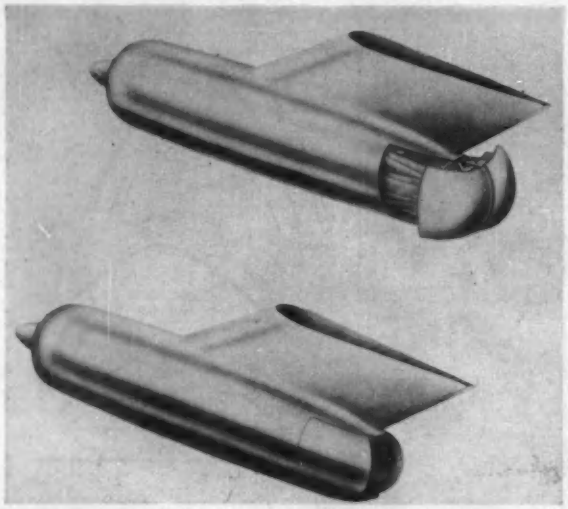

Fig. 6 — Thrust reverser is integral part of TJ38 engine and forms continuation of pod lines in stowed position.

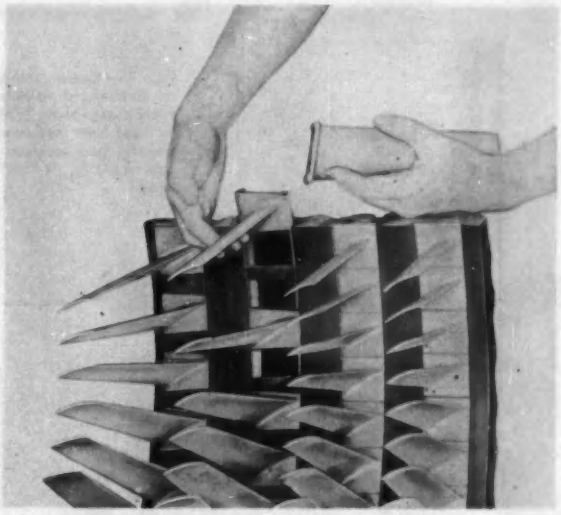

Fig. 7— Accessibility is featured in low-pressure compressor housing. One-half of housing can be removed to get at rotor for inspection and for replacement of stator blades.

TJ38 Zephyr Commercial Turbojet

. . . continued

turbine blading and other hot section parts. High-temperature turbojets operating in the 1600–1700 F range are limited by the stress rupture properties of the material. Even though the material be of the best obtainable, its life at 1700 F is limited to approximately 10 hr (the equivalent of a longer overhaul period as cruise is at considerably lower temperature). In contrast, the TJ38, using turbine inlet temperatures of 1340 F for standard day take-offs, could have a turbine life of 50,000 hr.

Other advantages of the low turbine temperatures are illustrated by Fig. 4. Here are plotted (1) the maximum allowable temperature for a 30-hr stress rupture life of a typical high-temperature turbine blade material at typical stresses, (2) the radial temperature profile which results from various combustion-chamber configurations and, (3) the TJ38 temperature distribution. The advantages are obvious. There is greater freedom in selection of combustion-chamber configurations to obtain peak performance, since the engine is operating far from the allowable limits of the material. Leaks, combustion-chamber-wall distortion, cracks, and other items that will shift the temperature profile cause no turbine blade problem in the low-temperature engine, even in the case of hot-day take-off.

Experience indicates no firm trend of vibratory stress which can be attributed to change in turbine temperature. The theoretical considerations are far overshadowed by the mechanical design features such as the number of struts up and down stream of the turbine, blade natural frequency, and turbine design speed.

A further advantage of the low turbine temperature is the margin available for hot starts, and over-temperature experienced during accelerations. The TJ38 turbine temperature is over 300 F lower than other comparable thrust engines and this margin can be used to reduce or even eliminate the special inspections required on the high-temperature engines because of the occasional over-temperatures encountered.

Thrust Reverser

A fully modulating thrust reverser is provided as an integral part of the engine. Its advantages as a supplemental braking mechanism during landing roll are evident in Fig. 5. By movement of the power lever control, a smooth transition can be made from full forward thrust to full reverser thrust. Thus, it has the potential of permitting rapid descents and steeper approach flight paths during airport entry when satisfactory procedures have been developed. The engine's acceleration and the fast response rate of the reverser allow use of a single-lever control, and rapid power recovery for "go-arounds" is available with minimum pilot attention to engine controls.

As shown in Fig. 6, the thrust reverser forms a continuation of the normal aircraft pod lines in the stowed position and provides the lightest reverser configuration devised to date.

Ease of Maintenance

The low-pressure, cast-magnesium compressor housing is an example of one of the several design features making for ease of maintenance. It is

made in two halves and joined at the split line by bolts. This design makes possible removal of one or both halves for compressor rotor inspection and stator blade replacement without further disassembly of the engine. The stator blades incorporate dovetail retention and slide directly into slots in the compressor casing, as shown in Fig. 7.

The high-pressure compressor rotor consists of seven axial-flow stages producing a 3.7/1 pressure ratio and is similar in construction to the low-pressure rotor. Because of the high temperature encountered in this area, steel has been used throughout the high-pressure system. The stator casing is made from centrifugally cast steel rings and the split line design of the compressor is the same as used for the low-pressure housing (Fig. 8). Each case half can be removed quickly for easy access to the rotor and stator blades. If necessary, half of the low-pressure compressor and half of the high-pressure compressor casing can be removed at the same time without using elaborate supports to prevent engine buckling.

The combustion-chamber housing also is of the split case design. Removal of one-half of the housing exposes four of the eight cannular combustion chambers. Any chamber can be lifted out for complete inspection by removing a few attaching bolts. Moreover, to the rear of each combustion chamber is attached a ⅛ segment of the high-pressure turbine stator blade assembly which facilitates stator blade inspection. The arrangement also makes for a light design because it eliminates a portion of the support hardware previously required for stator blade assemblies. With a single combustion chamber removed, all turbine rotor blades can be inspected by turning the rotor through the space vacated by the stator blade segment.

The turbine can be removed as a complete assembly and replaced with a new one to put the engine back into service. And it can be done with the engine in a horizontal position. The low-pressure and high-pressure turbine rotors are balanced independently and have moment weight blades which permit the replacement of individual blades without rebalancing of the engine.

All major units of the engine can be subassembled on the bench prior to main engine assembly. Major sections of the engine can be assembled to each other in the horizontal position, thus providing ease of handling in the field and at major engine overhaul.

Weight Advantages

The low engine weight of the TJ38 is due in part to some of the following features:

The compressor was designed with a high airflow per unit frontal area. Furthermore, a high-pressure rise per stage was utilized so that a pressure ratio of 10/1 is achieved in only 12 compressor stages. The moderate pressure ratio and careful splitting of work between high- and low-pressure systems resulted in the need for only one turbine stage per compressor spool.

Twin spool design, with moderate pressure ratio, provides surge-free operation over an extreme range of rpm and altitude conditions. It eliminates the need for compressor blow-off valves of variable geometry stators, which add weight and complexity. These and other features mentioned result in a basic weight of 3600 lb, which compares most favorably with current high specific thrust engines in the 10,000–13,000-lb thrust class.

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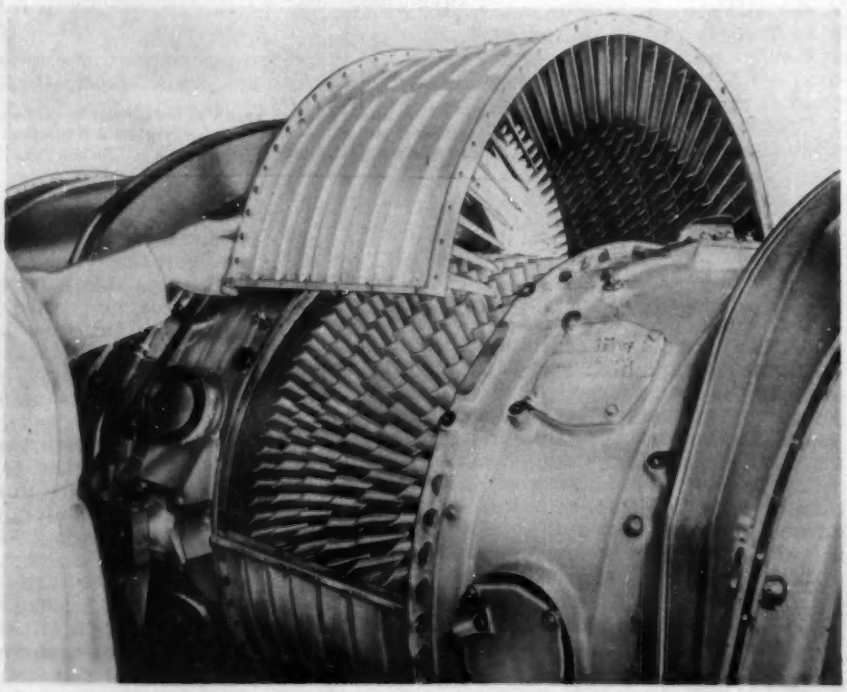

Fig. 8 — Stator casing of high-pressure compressor is made from centrifugally cast steel rings in split design similar to that of low-pressure housing. Only half of case need be removed to get at rotor and stator blades.

The Path of Progress . . .

Manned Aircraft to

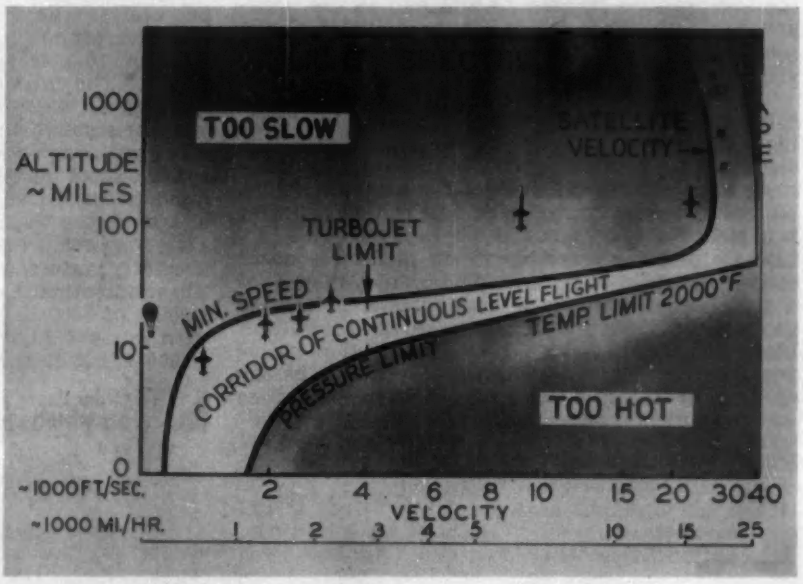

Fig. 1 — A narrow channel, known as the corridor of continuous flight, represents the possible combinations of altitude and Mach number in which it is practical to progress from advanced research aircraft to manned satellites.

Based on paper by

K. E. Van Every

Douglas Aircraft Co., Inc.

MANNED aircraft will continue to be developed for flight at very high speeds and high altitudes and the the experiences gained will serve as stepping stones to eventual manned satellites and space vehicles. The major problems to be solved relate to aerodynamic heating, stability, and control.

The possible combinations of altitude and Mach number in which it is practical to progress from advanced research aircraft to manned satellites is very limited. There is only a narrow channel known as the "corridor of continuous flight" (Fig. 1).

Meaning of Boundary Limits

The upper boundary line (Fig. 1) is the minimum speed at which continuous flight is possible, hence at low speeds this is a function of the airplane configuration (weight, wing area, aspect ratio and power available). By radical changes in configuration it can be pushed upward but at a sacrifice of other capabilities of the airplane. For an average type configuration, capable of flying supersonically, the minimum speed is of the order of 170 mph, which is the value used as the boundary.

At very high speeds the aerodynamic lift will be augmented by centrifugal force and eventually at satellite speeds the centrifugal force supplies the entire lifting force to keep the vehicle in orbit.

The lower boundary of the corridor is essentially a temperature limit (except for the extreme left portion, which is restricted by the maximum engine pressure) and as such depends largely upon the type of material of construction. It is assumed that the basic structure is critical and that sufficient cooling is provided for equipment and the pilot. It should be noted that this limit is established on the basis

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Section Paper

Manned Satellites

of stabilized conditions, not transient and for that reason may be too extreme for vehicles having a short time of operation. Future developments may be expected to push this limit to lower levels.

Problems of Aerodynamic Heating

Since aerodynamic heating is one of the most serious problems encountered in high-speed flight or on re-entry into the earth's atmosphere, much study has been given to flight paths, together with suitable materials and techniques for keeping the attainable temperatures within reasonable limits. The influence of the flight path on temperature 1 ft behind the leading edge is shown in Fig. 2. The design flight path of 38 deg was chosen by the resultant load factor on the pilot. Less severe heating problems can be obtained by choosing flight paths having lower maximum altitudes and thus the problem of aerodynamic heating can be explored gradually by building up to the design flight path in easy steps.

The most critical portion of the aircraft from this heating viewpoint is the wing leading edge or stagnation point. A typical value of the skin temperature is obtained by computing the temperature 1 ft back from the leading edge, which is shown in comparison with the stagnation value in Fig. 3. Although very high values of temperature do occur, the time for which they persist is quite short, being of the order of 50-sec duration.

Methods of Reducing Skin Temperature

One method of reducing skin temperature is to employ a blunt leading edge on the wing airfoil. Fig. 4 shows the effect of bluntness on the D558-III research aircraft configuration. Leading edge bluntness is a general phenomenon and has application to all types of re-entry vehicles. This idea (originally advanced by H. Julian Allen) depends upon making the wave drag a large portion of the total drag, thus reducing skin friction which gives rise to the aerodynamic heating.

Another method of reducing skin temperature is to increase the thickness of the material and thus the heat sink capacity in the critical areas. Appreciable reductions also can be made by using exterior insulating coatings. This is one of the most effective methods and the development of a suitable insulating coating should be vigorously pursued.

It is extremely important to know the type of boundary layer over the airfoil surface. The heat transfer coefficient which determines the temperature attained within a given time period is many times as large for turbulent as for laminar flow. The boundary layer type, therefore, can affect the

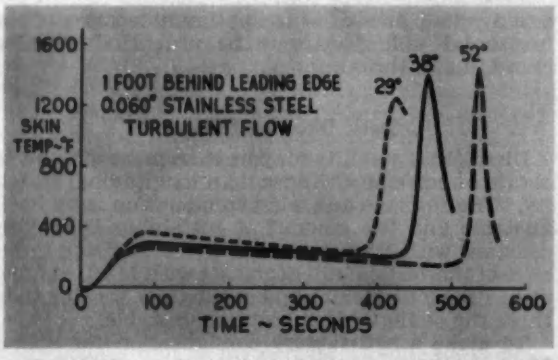

Fig. 2 — Influence of flight path on skin temperature 1 ft behind the leading edge.

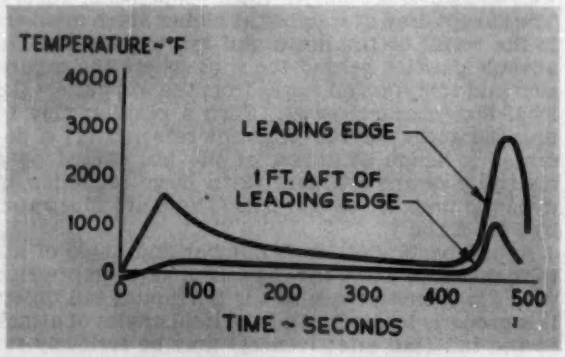

Fig. 3 — Skin temperature 1 ft back from the leading edge shown in comparison with the stagnation value.

The Path of Progress . . .

Manned Aircraft to Manned Satellites

continued

weight of the structure markedly, since if it is certain that a laminar boundary layer exists the structure can be made considerably lighter than if dealing with a turbulent boundary layer.

Unfortunately, information on the type of boundary layer is in a very confused state, hence it is extremely hazardous to predict which type of boundary layer will occur for a specific configuration under a specific flight condition. The possible difference in temperature on a specific configuration in shown in Fig. 5.

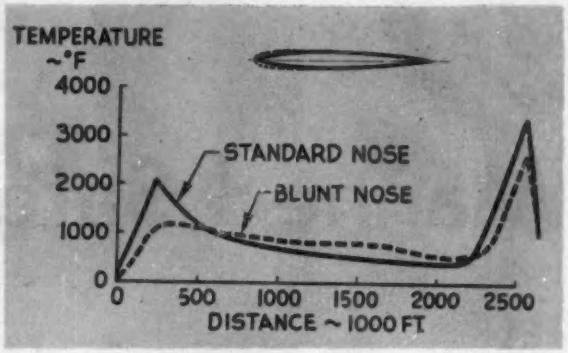

Fig. 4 — Blunting the leading edge on the wing airfoil is one way of reducing skin temperature. Here is shown the effect of bluntness on temperature at the leading edge of the D558-III research aircraft configuration.

Stability and Control Problems

Very high speeds and high altitudes magnify the stability and control problems previously met in the moderately high supersonic speed region. This is due to the tendency of the configuration to become more extreme — fuselages are necessarily longer and slimmer and wings become ever smaller in relation to fuselage size. At the same time the actual airplane density is increasing while the higher operational altitude results in reduced air density and hence greatly increased relative density, which is the most important factor contributing to a deterioration in the damping of dynamic oscillations. Basic Mach number effects are also intensified as speed increases and they are often complex and irregular in nature as a result of shock wave interference effects.

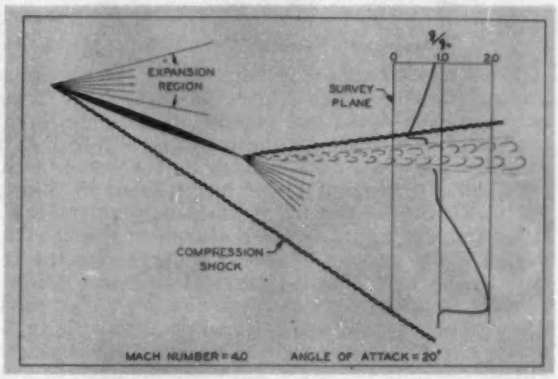

Fig. 7 — Optimum location of horizontal tail for reduction of dynamic pressure is near the extended chord line of the wing. Here are shown the possible reductions in dynamic pressure behind wings at supersonic speed.

Static Longitudinal Stability

Longitudinal stability changes occur with Mach number and the stability may become neutral or even negative for some particular Mach number. The gradual but definite decrease with increasing Mach number is a consequence of the lift available on the tail as a function of Mach number, which is well known from simple linear supersonic theory. The abrupt drop of stability at higher Mach numbers is the result of the horizontal tail moving into an adverse position behind the wing where the expansion and compression waves from the wing affect the local flow characteristics. Such a position may be unsatisfactory for two different reasons: (1) a decrease in angle of attack of the tail caused by a changing downwash, and (2) a large reduction in dynamic pressure at the tail. These are illustrated by Figs. 6 and 7.

At the particular Mach number and angle of attack shown in Fig. 6 the expansion and compression waves may interfere with the horizontal tail unless it is properly located. And the local angles of attack at the tail (tail effectiveness) may be seriously reduced. A tail located at high position A and location D would be severely affected. The optimum practical location for this set of conditions would appear to be on or near the extended wing chord line at C.

Fig. 7 shows the possible reductions in dynamic pressure. In the expansion region this pressure is reduced, whereas abrupt increases occur through compression shocks.

In consideration of both these effects — downwash and dynamic pressure — an optimum location of the horizontal tail appears to be near the extended chord line of the wing.

Static Directional Stability

Directional stability may be even more difficult to obtain at extreme altitudes than longitudinal stability. The fuselage and wing combination is by itself unstable and the amount of instability is roughly constant with Mach number. The stabilizing influence of the vertical tail decreases with Mach number until finally at Mach numbers slightly greater than three the configuration becomes unstable.

To make a satisfactory configuration for higher Mach numbers requires additional vertical surface area, as shown in Fig. 8. And this can be done most

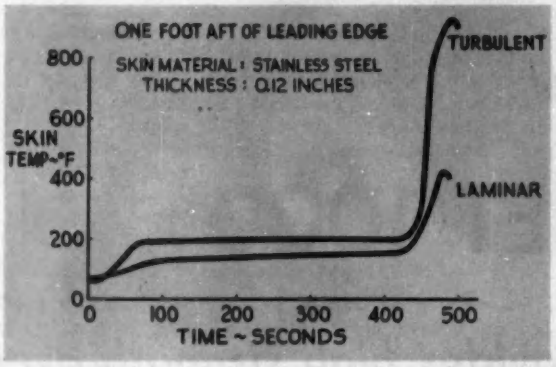

Fig. 5 — Possible difference in temperature on a specific configuration illustrates the great importance of boundary layer type.

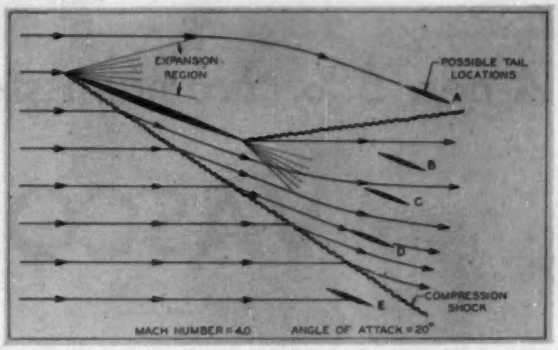

Fig. 6 — Flow direction lines at supersonic speed indicate qualitatively the angles of attack experienced by a tail surface located at several possible vertical positions aft of the wing.

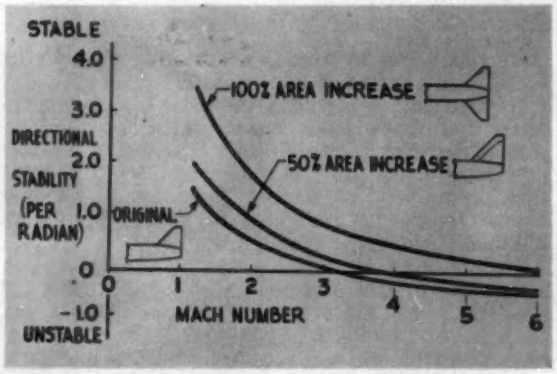

Fig. 8 — Effects of tail size on directional stability. Additional vertical surface area is required to a make a satisfactory configuration for higher Mach numbers.

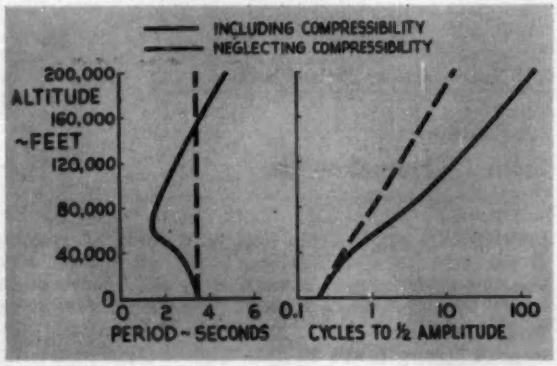

Fig. 9 — Damping ratio of longitudinal and lateral oscillatory motion (neglecting compressibility effects) is directly proportional to the square root of air density, producing typical variations with altitude.

efficiently by distributing it equally above and below the fuselage.

Inertia Coupling

Basically, inertia coupling arises as a result of coupling of the longitudinal and lateral modes of motion and usually becomes severe only when resonance between rolling and pitching or yawing motions occur. The problem can be eliminated by avoiding flight conditions in which resonance occurs. This is generally impractical, hence the designer must strive to minimize the magnitude of the disturbance by proper design.

High-Altitude Damping

Operation at high altitudes will result in almost complete loss in damping of the aircraft's longitudinal and lateral short-period modes of motion. Neglecting compressibility effects, the damping ratio of either oscillatory motion is directly proportional to the square root of air density, producing typical variations with altitude, as shown in Fig. 9.

Within the earth's atmosphere the use of automatic stabilization devices, such as pitch and yaw dampers, will compensate satisfactorily for the loss in damping. But a better approach is to employ fundamental aerodynamic solutions wherever possible and use artificial stabilization only after it is definite that it is superior to a more basic approach.

Control Outside the Atmosphere

Two methods of control outside the atmosphere were considered in this study. They were (1) jet reaction and (2) gyroscopic effect of a rotating flywheel. From a weight standpoint the simple jet reaction system was found to be best. It consisted of a source of hydrogen peroxide (monopropellant) with small control jets suitably located on the air plane to enable the pilot to make lateral, longitudinal, and directional corrections to a flight path. The most important use is to enable the pilot to align the aircraft with the flight path before reentry into the earth's atmosphere.

To Order Paper No. S80 . . .
. . . on which this article is based, turn to page 5.

A new 5% chromium steel

VASCOJET 1000

provides high strength over wide temperature ranges.

Abridgment of an
SAE Southern New England Section Paper

Based on paper by

John C. Hamaker, Jr.
Vanadium-Alloys Steel Co.

UTILIZING an entirely new heat-treating concept for structural materials, a 5% chromium steel VascoJet 1000 is demonstrating outstanding advantages for high-strength parts operating at temperatures between –100 F and 1000 F. Fatigue and impact strength are 20–35% higher than other air-melted materials. And, elevated temperature strength-to-weight ratio surpasses the heat-treated titanium alloys.

These advantages are obtained with an inexpensive, low strategic alloy content (0.4% C, 5% Cr, 1.3% Mo, 0.5% V, balance Fe) that provides ease of forging, cold working, machining, and welding equivalent to low-alloy steel.

Recent developments in surface protection, made possible by the unique heat treatment, afford excellent corrosion and oxidation resistance with no embrittlement of the high-strength core. A wide variety of components in airframes, landing gear, missiles, and jet engines, as well as bolts, springs, gears, and other hardware, are being fabricated from bars, billets, extrusions, sheet, and wire of this composition.

Heat Treatment

The exceptional properties of VascoJet 1000 are directly related to its unique heat treatment. Possessing deep hardenability, it fully hardens through sections as large as 20 in. cube by simply air cooling from 1850 F. With the slow, uniform air cool, the drastic quenching stresses of oil-hardened low-alloy steels are avoided, and movement and distortion are practically eliminated. Large airframe parts, fully machined prior to heat treatment, with drastic changes in section (from 5 in. diameter to 0.065 in. thick structural webbing) are being hardened to close tolerances by simply suspending without fixtures in a controlled-atmosphere furnace.

Of even greater significance is the high tempering range permitted by a metallurgical phenomenon called "secondary hardening." Caused by uniform precipitation of alloy carbides through the structure, secondary hardening produces a hardness versus tempering temperature curve having the characteristic shape shown in Fig. 1.

Rather than softening steadily with increasing temperature, like the low alloy and martensitic stainless steels, materials of this type reach a peak hardness and strength at 950–1000 F. From preliminary research on many alloys, the 5% chromium steel was found to be the lowest alloy composition, with corresponding maximum toughness, that provided a true secondary hardening reaction. The benefits are threefold:

1. The high tempering treatment (above 950 F) provides essentially complete removal of residual hardening stresses. Low-alloy steels, oil quenched and tempered in the 400–700 F temperature range to achieve similar strength levels, may contain very high "locked-in" heat-treating stresses that seriously detract from the load-carrying ability of the part.
2. Tests at various laboratories have shown conclusively that multiple tempering VascoJet 1000 in this range removes all trace of retained austenite (less than 1%), even at the highest tensile levels. Despite refrigeration and baking treatments, low-alloy, high-strength steels tend to contain appreciable quantities of unstable austenite which is capable of transforming to brittle martensite at low stress levels and thereby decreasing ductility and fatigue strength in operation.
3. Finally, secondary hardening provides high elevated-temperature strength and predictable structural stability, resulting in stable hot tensile, creep, and rupture properties. The effect of time at elevated temperatures has been precisely related for steels of this type by the Holloman-Jaffe and Larson-Miller parameter,

shown along the horizontal axis of Fig. 1. Using this formula, it is possible to calculate the initial strength level that can be stably maintained over a given set of operating temperatures and times. For atomic energy components, it has been calculated that 290,000 psi tensile strength should be maintained after 1,000,000 hr at 700 F. Conversely, missile applications of very short life may retain a stable high-strength structure to 1100–1200 F.

Low-Temperature Properties

Fig. 2 shows the effect of tempering temperature, after hardening by air cooling from 1850 F, on the hardness and strength of VascoJet 1000. Any desired tensile strength from 150,000–300,000 psi can be readily obtained by simply adjusting the tempering temperature between 950 and 1200 F with no danger of encountering an embrittlement range. Over most of the strength range, compressive yield strength is 25,000 psi higher than the tensile yield values shown in Fig. 2.

Based on the parallelism of the hardness, tensile, and yield strength curves in Fig. 2, strength versus hardness plots similar to Fig. 3 have been prepared from hundreds of longitudinal and transverse tests on specimens ranging from thin sheet to the centers of 16 in. square billets. These plots transcend slight variations in heat-treating equipment and are permitting quality control laboratories to inspect and guarantee ultra-high-strength properties in complex parts by simple hardness inspection. Sheet yield strengths are running considerably higher than shown in Fig. 3, with consistent values only 25,000 psi below the tensile strength. Yield values averaging 285,000 psi have been obtained from welded sheet specimens tested for missile applications.

Fig. 4 shows the toughness and ductility of this material. The absence of an embrittlement range permits the V-notch Charpy impact strength and elongation to vary in direct proportion to the tensile strength. Note that comparative data for 4340 and 4340 plus 1.5% silicon, reported by Shih, Averbach, and Cohen (Transactions ASM, Volume 48, 1955), shows a very definite minimum in the vicinity of 260,000 psi tensile strength due to the "500 F embrittlement" phenomenon. The apparent increase in impact and ductility of the 4340 types at 280,000–300,000 psi is attributable to retained austenite, an unstable component in the steel structure that has very low yield strength and tends to transform to brittle martensite under repeated stress with a marked reduction in properties.

The impact values for the 5% chromium steel of 15–20 ft-lb in the 250,000–300,000 psi range are considered quite adequate for most structural applications. Similar V-notch Charpy tests, cut tranversely from the midradius of a 15½ in. × 4 ft billet still retained values of 12–13 ft-lb at the 260,000 psi tensile level. With regard to low-temperature properties, the bar impact strength is 15 ft-lb at – 100 F with a completely fibrous fracture. As indicated in Fig. 5, this 15 ft-lb point plots smoothly on the impact versus test temperature curve, indicating a transition temperature below – 100 F.

Transverse ductility in large billets, of prime importance to landing gear design and the manufac-

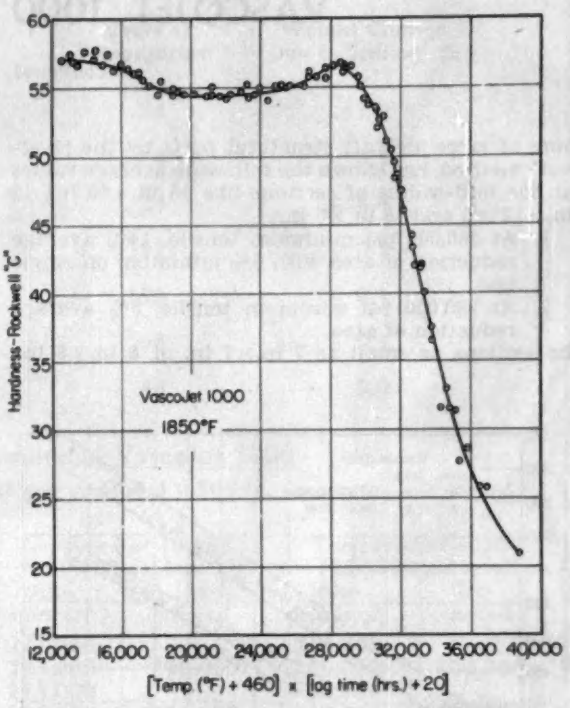

Fig. 1 — Master tempering curve for VascoJet 1000. Allowable operating temperatures and times for maintaining stable elevated temperature properties can be precisely calculated from formula shown on horizontal axis.

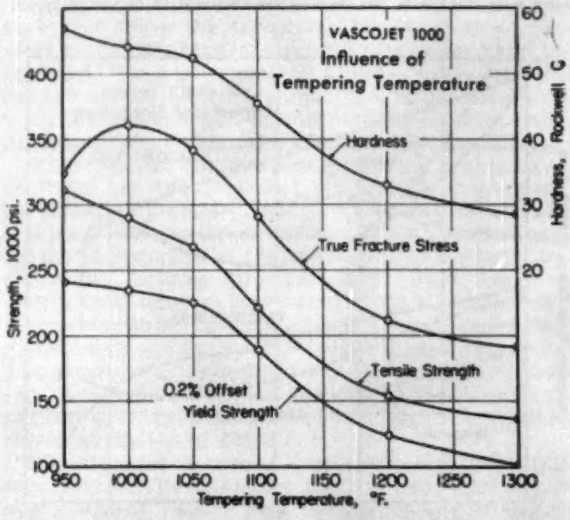

Fig. 2 — All strength levels from 150,000-300,000 psi tensile are attainable in VascoJet 1000 by adjusting the tempering temperature between 950 and 1200 F.

A new 5% chromium steel

VASCOJET 1000

continued

ture of large aircraft structural parts by the "hog-out" method, has shown the following average values at the mid-radius of sections like 15 in. × 15 in., 12 in. × 12 in., and 18 in. × 5 in.:

1. At 260,000 psi minimum tensile, 14% average reduction of area with 8% minimum on single test.
2. At 280,000 psi minimum tensile, 5% average reduction of area.

In sections as small as 7 in. × 7 in. or 8 in. × 8 in., values at the center of the billet correspond with those given in (1.) above.

As shown in Fig. 6, the fatigue strength of this steel is the highest yet reported for any air melted engineering material, with 130,000 psi endurance limit at the 260,000 psi tensile level. Additional tension fatigue tests, run on threaded aircraft fasteners at room and elevated temperatures, have confirmed these results.

Elevated Temperature Properties

Fig. 5 shows the effect of operating temperature on the strength, ductility, and toughness properties of VascoJet 1000 initially treated to 260,000 psi tensile strength at room temperature. Note that over 200,000 psi tensile strength is retained at 900 F, with an elongation of 10% and impact of about 30 ft-lb over the entire elevated temperature range. Initially heat treating to 290,000 psi room temperature

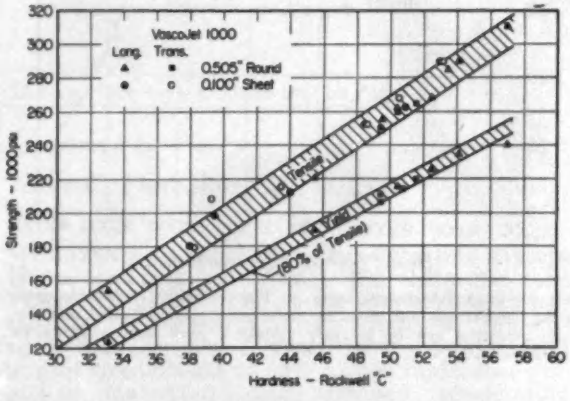

Fig. 3 — Typical quality control plot insures strength of complex parts by hardness inspection. Points obtained from longitudinal and transverse tests range from thin sheet to the center of 16 in. square billets.

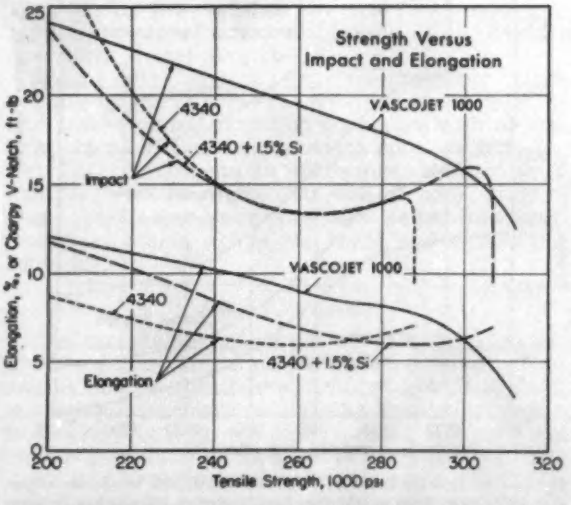

Fig. 4 — Impact toughness and ductility of the 5% chromium steel are 20-35% higher than 4340 types at high-strength levels. With no embrittlement range or retained austenite, they vary proportionately with tensile strength.

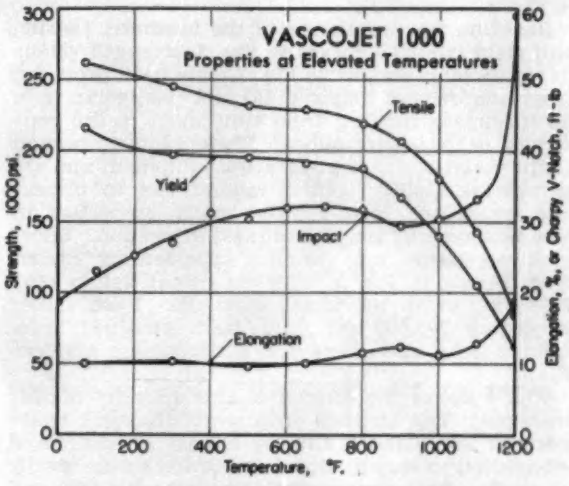

Fig. 5 — Elevated temperature strength, ductility, and toughness at various operating temperatures. Properties shown are stable after extended exposure to 1000 F.

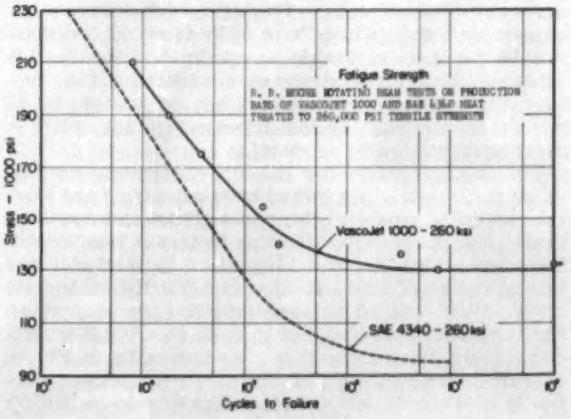

Fig. 6 — From 8000-100,000,000 cycles, the fatigue strength of VascoJet 1000 is 10-35% greater than any air melted material previously reported.

Table 1 — Oxidation Resistance from Aluminizing Compared with Stainless Steel

Material	Temperature, deg F	Hours at Temperature	Weight Change Due to Scaling, %
Untreated 18-8 Stainless	1350	24	–17.0
Untreated 25-20 Stainless	1350	4	– 8.3
Untreated 27% Cr Stainless	1350	24	– 8.4
Aluminized Carbon Steel	1350	192	+ 0.1
Aluminized 18-8 Stainless	1350	192	+ 0.1
Aluminized Carbon Steel	1700	48	+ 0.3
Aluminized 18-8 Stainless	1700	48	0.0

Tensile Properties of Aluminized VascoJet 1000

Comparison of aluminized (0.006 in. case depth) and uncoated 0.505 in. specimens, air cooled from 1850 F and tempered 2½ + 2½ hr.

	Tempered at 1000 F (290,000 psi level)		Tempered at 1050 F (260,000 psi level)	
	Alu-minized	Un-coated	Alu-minized	Un-coated
Tensile Strength from Specimen Diameter	271,000		244,000	
Tensile Strength from Core Diameter	285,000	290,000	256,000	268,000
Yield Strength from Specimen Diameter	215,000		203,000	
Yield Strength from Core Diameter	226,000	235,000	215,000	226,000
Reduction of Area, %	26.0	28.1	35.9	31.9
Elongation, %	7.6	7.8	9.6	8.5

strength provides proportionately higher hot strength at all temperatures.

Cold and Hot Fabrication

In the annealed condition, VascoJet 1000 is practically dead soft (180–210 Brinell) and readily machinable. For fine finish machining, a prehardening treatment to Rockwell C 30 is sometimes employed. In the fully hardened condition (50–56 Rockwell C), successful high-speed broaching and drilling on assembly have been reported.

Surface Protection

Where maximum corrosion and oxidation resistance are required, three surface protection methods, two unique to the steel, are available

Diffused nickel-cadmium plating (originally described by Noble and Sharp in SAE Transactions, Volume 64, 1956 and approved as AMS Specification 2416) is being successfully applied to engine parts and high-temperature aircraft fasteners. According to test data, this procedure, involving only a few ten-thousandths of successive nickel and cadmium plates followed by a high-temperature diffusion treatment, is equivalent to a 0.002 in. nickel plate in corrosion resistance and is oxidation resistant to 1000 F with no danger of stress alloying embrittlement. Recent notch tests on nickel-cadmium plated VascoJet 1000 showed complete recovery from hydrogen embrittlement on baking at 850 F, a temperature well below the tempering temperature of the steel so that the highest strength properties could be retained. This is considered a major breakthrough in high-strength steel technology — both a steel and a plating method that permit sufficiently high baking temperatures for complete hydrogen removal.

Where higher temperature protection and thicker coatings are required, hot-dip aluminizing offers considerable promise. The finished machined part is dipped into molten aluminum at 1350 F and then hardened normally at 1850 F, during which time the aluminum diffuses into the steel. This forms a ductile solid solution layer, 0.003–0.006 in. thick, having an aluminum content of 5–15%, and resembling quite closely the high-temperature alloy Thermenol. The excellent oxidation resistance of the aluminized case to temperatures as high as 1350–1750 F, in comparison with simultaneous tests on stainless steel, is shown at the top of Table 1.

The aluminized case is vastly different from the relatively brittle calorized steel or iron-aluminum alloys studied in the past. Diffusion temperatures above 1750 F, permitted by the 1850 F hardening temperature of this steel, are necessary for developing ductility in the case. The bottom of Table 1 shows the result of tensile tests on aluminized 5% chromium steel, in which the core strength and the

A new 5% chromium steel

VASCOJET 1000

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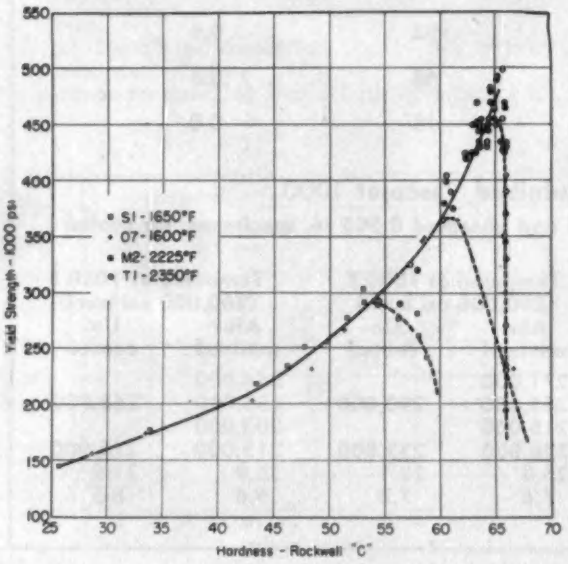

Fig. 7 — Consistent relationship of bend yield strength to hardness for several medium to high alloy steels. Each steel achieves its maximum strength at a different hardness level, above which undertempering causes the progressive loss shown by the dotted lines.

Table 2 — Physical Properties of VascoJet 1000

Composition:
0.4% C, 5% Cr, 1.3% Mo, 0.5% V

Density: 7.75 g per cc (0.28 lb per cu in.)

Mean Coefficient of Thermal Expansion, in. per in. per deg F × 10^6		Thermal conductivity, Btu per sq ft per hr per deg F per in	
80- 200 F	6.1		
80- 400 F	6.5	420 F	199
80- 800 F	7.1	660 F	197
80-1200 F	7.4	890 F	196
500-1200 F	7.8	1120 F	199
800-1200 F	8.1		

Notes on Heat Treatment

Forging:
Start at 2000 F, stop at 1600 F; slow cool in insulating medium.

Annealing:
1500-1550 F; cool at 50 deg per hr to 1000 F; Brinell 183 to 202.

Welding:
Preheat to 1000 F; weld with shielded arc; maintain temperature above 600 F; slow cool in furnace or insulating medium; full anneal.

Hardening:
Preheat at 1450 F; hold 20-30 min at 1800-1900 F in protective compound, salt, or atmosphere; air cool to room temperature.

Tempering:
Double temper at 950-1200 F; time and temperature depend on size and hardness desired.

ductility reveal no deleterious effects from the aluminizing treatment.

A third coating used extensively on aircraft parts at temperatures up to 800–1000 F is heat-resistant paint.

For maximum wear resistance, this 5% chromium steel nitrides as effectively as the nitralloys but, in addition, retains full hardness and strength in the core because the nitriding temperature is below the tempering temperature.

Physical Properties

As shown in Table 2 the thermal expansion of 5% chromium steel is low compared to the superalloys and stainless steel, and provides excellent material for use in conjunction with titanium. Its thermal conductivity is also high in comparison with some other materials. The modulus of elasticity of this steel is 30,000,000–32,000,000 psi at room temperature, decreasing to 23,000,000–25,000,000 psi at 1000 F, providing considerable stiffness advantage over aluminum or titanium alloys. Notes on various hot working and heat-treating operations are also included in Table 2.

Future Developments

Two avenues are being actively investigated for potential new materials in this ultra-high-strength, heat-resisting steel field.

One consists of maintaining high hot strength at temperatures beyond 1000 F, thereby bridging the gap between VascoJet 1000, and the lower strength superalloys used for 1300–1800 F jet-engine applications. For this research, emphasis is being placed on strength rather than oxidation resistance, in view of the rapid developments in protective-coating technology. A number of promising alloys are being tested, including a production steel providing stable hot strength to 1100–1150 F, and an experimental steel that resists softening up to rehardening temperatures. As might be expected, greater heat resistance necessitates higher alloy contents with a

corresponding reduction in ductility at the highest strength levels.

The other approach leads toward higher room-temperature strength in the tensile range beyond 300,000 psi. Due to the inaccuracy and uncertainty of tensile testing at hardnesses beyond 56–57 Rockwell C, the bend test is being used to measure strength and ductility at hardness levels up to 65 Rockwell C.

Some interesting indications have been obtained from a series of investigations. As shown in Fig. 7, each composition has a specific hardness level for maximum bend yield strength, and higher hardness may result in loss of strength due to insufficient tempering. High speed steels (T1 and M2) develop the highest strength available in any existing material, showing a proportional increase in strength with hardness up to about 450,000 psi bend yield, which is equivalent to 390,000 psi tensile yield strength. This strength is obtained at a sacrifice of ductility that would necessitate drastic changes in structural design criteria on notches, stress raisers, shock resistance, and such.

Many additional compositions are being studied in an effort to develop adequate structural ductility at strength levels above 300,000 psi. Although occasional laboratory tests achieve 350,000 to 400,000 psi tensile strength, true design values like yield and fatigue strength are usually quite low, and frequently below the level of the 5% chromium steel at 300,000 psi. Consistently obtaining these properties in production parts, as is now being done at 290,000–300,000 psi, is also an unknown quantity. For the immediate future, the 300,000 psi tensile level appears to present a plateau for high-strength structural materials that meet present design requirements for ductility, notch sensitivity, fatigue strength, and shock resistance.

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. . . on which this article is based, turn to page 5.

Use proved designs for

Missile Hydraulic Systems

Based on paper by

H. J. Ide

Douglas Aircraft Co., Inc.

MISSILE MANUFACTURERS want hydraulic systems that are designed and produced fast and still have work-every-time reliability.

To meet this challenge a missile maker follows three rules for today's designs and points to problems and some solutions for tomorrow's designs.

3 Rules for Design

- The best way to get both speed and reliability is to use conservative and proved designs. New and tricky parts can be developed and phased into such designs as they *prove* themselves. But the original design should not depend on their success.
- Hydraulic components should not be overlayed with duplicate-function parts; nor should equipment be added to solve problems that *might* arise. These extra parts can cause the failure of and add weight to the missile.
- Standard cartridge items should be used wherever possible. Such cartridges are groups of assembled parts that can be plugged into the missile. Not only does this save weight and space but it makes maintenance simpler and surer.

Hydraulic Developments Needed

High temperature is the problem which hydraulic engineers, as well as others, are trying to solve. Already fluid temperatures of 700 and 1000 F are being planned. Such temperatures may be encountered in cruise-type missiles. But for the ICBM type, which is under power for no more than 10 min, a temperature of 400 F seems more likely. Reasons: (1) time lag in heating up the hydraulic system during short flights through the atmosphere and (2) distribution of heat through the system by using the hydraulic fluid as a heat conductor.

Fluid contamination is a constant problem in high- or low-temperature systems. Critical valve clearances are under two microns (millionths of a meter). This means filtering out particles smaller than some bacteria. In fact, one contamination problem turned out to be a virus living in the oil. This high filtration level isn't necessary if clearances aren't held as close. One way to do this is to increase the electrical signal input by making use of new developments in transistors.

A stiff hydraulic system is needed to increase the natural frequency of the system. This reduces harmonic feedback and system instability. To achieve this stiffness, all the play or slop in the bearings, push-rods, bell cranks, and supporting structure must be minimized. A new problem coming with increased temperatures is loss in bulk modulus of the hydraulic fluid. This loss makes the fluid more compressible and adds softness to the system.

To Order Paper No. 48C . . .
. . . on which this article is based, turn to page 5.

The 1975 Supersonic Jet Will Fly at

The Mach 2+ transport demands:

High turbine inlet temperatures and better jet nozzle design from the engine builder.

Lift-to-drag ratios of 10 or better in supersonic flight from the airframe manufacturer.

Based on paper by

G. C. Rapp,
General Electric Co.

CHARACTERISTICS of 1970–1975 supersonic jet transports can be nailed down by examining today's commercial and military operations. At the same time the places where improvement is most needed can be pinpointed by engine cycle analysis combined with airframe aerodynamics.

What Will the Powerplant Look Like?

The turbojet engine is now the best bet for a jet transport operating up to Mach 2.5 and having a gross weight around 250,000 lb. The turbofan is now its closest competitor with an installed specific fuel consumption 5% less than that of the turbojet, plus a somewhat higher installed weight.

Engine cycle analysis and comparison with aircraft characteristics indicate engine parameters giving:

- A design pressure ratio of 8–12.
- A high turbine inlet temperature, 2000–2200 F for take-off.

The engine alone has a low specific fuel consumption at an inlet turbine temperature of 2060 R and a pressure ratio of 10. See Fig. 1 for flight at Mach 2.0. However, when these data are corrected for installed conditions the higher turbine temperature gives a lower specific fuel consumption. Fig 2 indicates this effect as a function of nacelle drag coefficient.

Another reason for high turbine inlet temperatures is the weight of the engine. For equal thrust the airflow goes up as turbine inlet temperature drops. Since the engine weight is closely related to airflow, the temperature should be kept high.

The biggest advances to be made on the supersonic engine are in the design of the exhaust nozzle. Better than three times the results can be expected from improvements in this area compared to any of the other four major engine components. Fig. 3 indicates that this effect is magnified as the flight speed goes up. This is in contrast to subsonic engines where compressor and burner efficiencies have been critical.

The external aerodynamics of the jet exhaust stream will be one of the main points to investigate. Little is known about the relationship between the

Transport

65,000 Ft

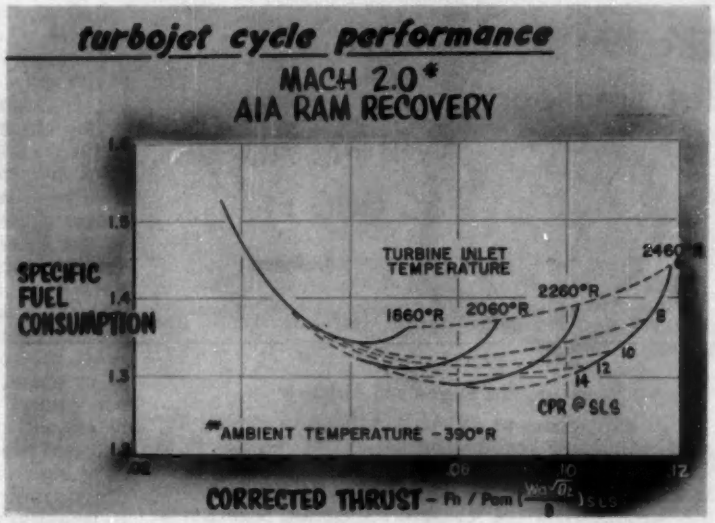

Fig. 1 — Several combinations of turbine inlet temperature and pressure ratio will give similar specific fuel consumption values for the engine alone. However, a low temperature is more detrimental than a low pressure ratio because the engine weight and size increase for a given thrust rating. This lowers the aircraft efficiency.

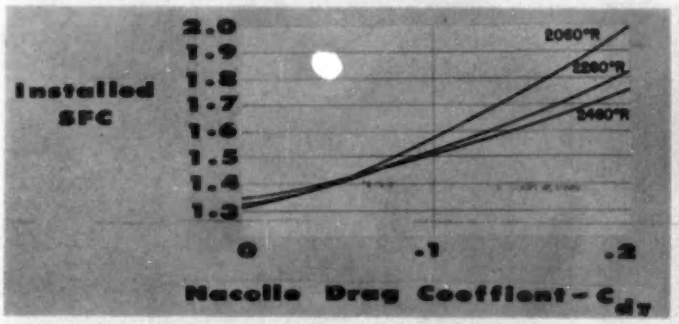

Fig. 2 — Nacelle drag also dictates a high inlet turbine temperature. Low temperatures mean larger engine frontal cross-sections. This gives a higher installed drag and a lower overall specific fuel consumption. The example shown is for Mach 2 flight with a sea level compressor compression ratio of 10.

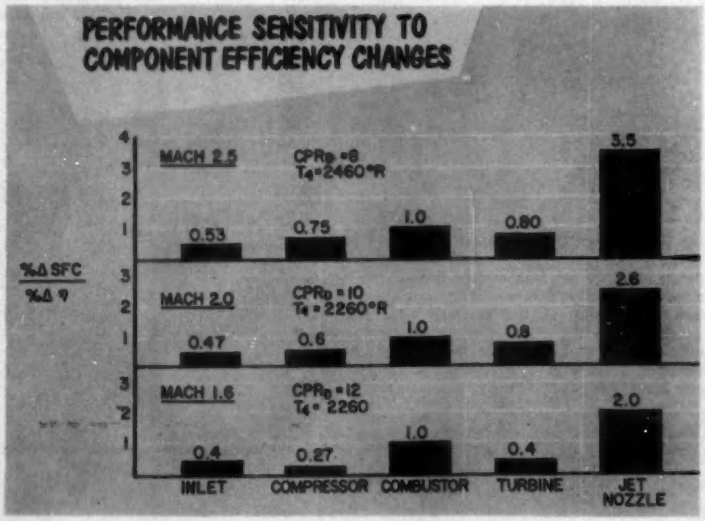

Fig. 3 — Of the five main engine components the jet nozzle offers the biggest increase in performance for an increase in efficiency. This is a change from subsonic flight where combustor and compressor efficiencies are emphasized.

The 1975 Supersonic Jet Transport Will Fly At 65,000 Ft.

continued

primary and secondary flows, particularly in the boundary layer.

Mating the Engine and Airframe

Cruise altitudes of 65,000 ft will be necessary for good efficiency (productivity). This results from the fact that the aircraft will have to operate at or near the maximum lift/drag ratio to approach the productivity of present subsonic transports. Also, the plane must continually increase its altitude as fuel is burned up to stay at the maximum *L/D* ratio.

L/D ratios of 10–12 are needed for flight speeds of Mach 2.0–2.5 to compare with subsonic transport productivity (ton-nautical miles per lb of fuel). Fig. 4 gives the effect of *L/D* on productivity and Fig. 5 shows its effect on initial cruise altitude.

The effect of engine weight on aircraft productivity shows up indirectly in Fig. 6. Here a high inlet turbine temperature steps up productivity. This high temperature means low engine weight.

One drawback of high turbine temperatures will be the increase in noise level. For commercial operation, sound suppressors are needed to keep the noise at an acceptable level.

Engines will be sized to permit take-off from a 9000-ft runway over a 50-ft obstacle if existing airports are to be used. If supersonic *L/D* ratios are 10 or above, the same engines will be well matched for cruise flight at maximum *L/D*. Lower *L/D* ratios will require oversized engines to keep a high value of productivity. This increase in size is necessary because the increase in engine weight is more than compensated for by the improved efficiencies in flying at or near maximum *L/D*.

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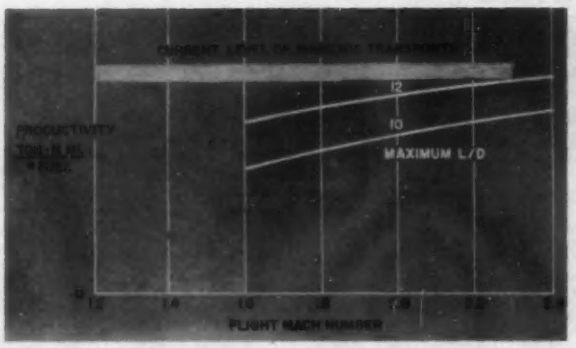

Fig. 4 — Supersonic transports must have a maximum lift-to-drag ratio of 10-12 to compete with their present subsonic counterparts.

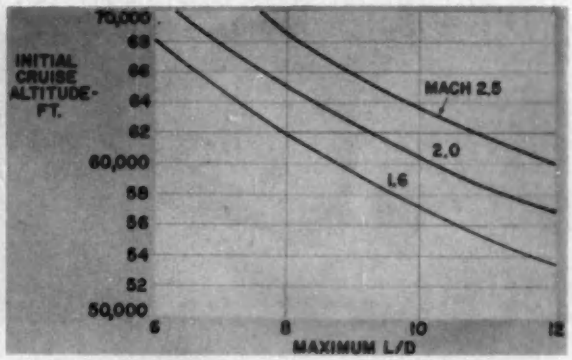

Fig. 5 — Cruising altitude will be determined by the maximum *L/D* ratio and the speed of the jet transport. During the flight the plane will have to climb to stay at maximum *L/D* ratio. This is because fuel weight is decreasing. The wing loading for this graph is 90.

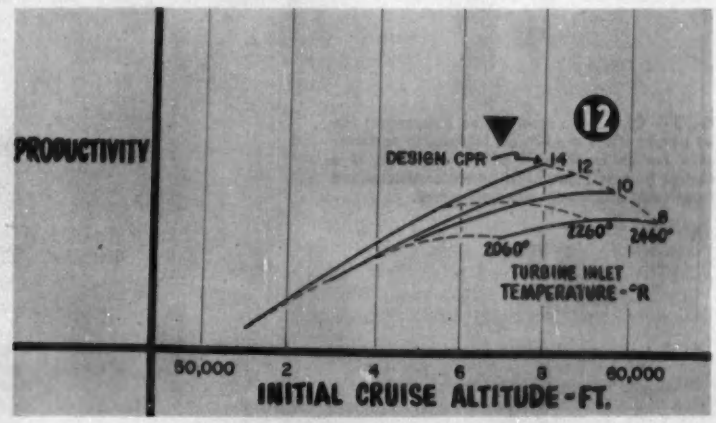

Fig. 6 — Turbine inlet temperature is much more critical than compressor compression ratio in determining the sea level airflow through the engine. This airflow determines the size and therefore the weight of the engine. Low engine weight is desirable since it improves the overall efficiency or productivity of the airplane. The example shown is for a maximum *L/D* ratio of 12 and Mach 2.0.

Abridged from an
SAE Detroit Section Paper

Foreign Car Specifications

listed in five groups according to size classifications

From paper by

G. A. Smith, Overseas Operations Division, GMC

(These data were obtained from 1/10 scale drawings, and the passenger's space and truck space measured as indicated by A and B in the accompanying illustration. . . . Accuracy might vary ± 5%, but comparisons remain valid. "Design date" shows the age of current-production models. . . . All these foreign models — except BMW 600, DKW, and Lloyd — have integral frame construction. . . . The 1958 Chevrolet is appended at the bottom.)

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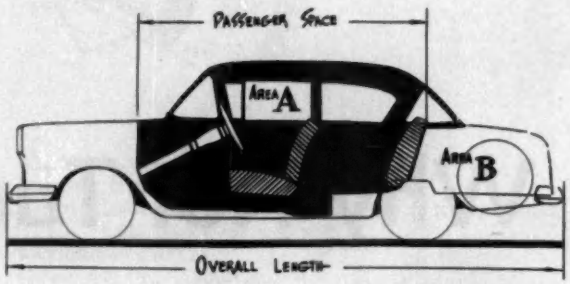


	Design Date	Curb Weight	Engine cc	Exterior Length	Exterior Width	Area sq ft	Interior Width	Interior Length	Area sq ft	Area A	Area B	Passenger Space	Weight per cu ft
Fiat — 500	1957	1036	479	116.0	52.0	41.8	43.5	74.0	22.3	19.0	2.2	69.0	15.0
Goggomobile	1955	851	247	114.2	50.4	40.0	42.0	76.0	22.2	16.9	1.5	59.2	14.4
BMW — 600 Sedan	1957	1164	585	114.2	55.0	43.5	43.0	74.0	22.0	18.9	0.9	68.0	17.1
Lloyd — 600	1955	1245	596	133.5	55.5	51.5	44.5	74.0	22.8	20.4	3.3	75.6	16.4
Citroen — 2 CV	1949	1124	425	148.8	58.3	60.3	45.0	82.0	25.7	23.2	4.5	87.0	12.9
Average (Under 600 cc)		1084										71.7	15.1
Fiat — 600	1955	1234	633	126.6	53.0	46.5	45.0	76.0	23.8	20.0	3.0	75.0	16.5
Renault — Dauphine	1956	1389	845	155.5	59.8	64.5	47.0	80.0	26.2	21.0	4.7	82.0	17.0
Morris Minor — 1000	1948	1751	948	148.0	61.0	62.7	47.5	82.5	27.2	21.9	3.9	86.8	20.2
Austin A-35	1951	1547	948	136.4	55.3	52.0	44.1	80.0	24.5	20.8	3.9	76.5	20.2
DKW — 3-6	1955	1973	903	166.3	66.7	77.0	49.6	81.0	27.9	22.3	5.2	92.0	21.4
Average (600-1000 cc)		1579										82.4	19.1
Volkswagen	1945	1609	1192	160.2	60.6	67.5	45.0	83.0	26.2	23.7	4.4	88.5	18.2
Ford — Angila — Prefect	1952	1699	1172	149.8	60.8	63.3	47.0	81.5	26.6	22.4	4.7	87.5	19.4
Simca — Aronde	1951	2050	1290	162.0	61.3	68.9	47.0	86.0	28.1	23.1	5.6	90.5	22.7
Fiat — 1100	1953	1841	1089	148.6	57.4	59.6	48.0	84.0	28.0	23.0	4.3	92.0	20.0
Hillman —Minx	1956	2200	1390	162.0	60.8	68.5	48.5	85.0	28.6	22.5	5.1	91.0	24.2
Average (1000-1400 cc)		1880										89.9	20.9
Opel — Olympia	1957	1995	1488	174.0	63.6	77.0	49.2	90.0	31.2	26.2	5.9	107.5	18.6
Peugeot — 403	1955	2359	1468	176.0	65.8	80.5	52.2	92.0	33.4	25.4	5.6	111.0	21.2
Austin A-55	1954	2310	1489	167.0	61.5	71.4	50.5	89.0	31.2	25.0	5.9	105.0	22.0
Vauxhall — Victor	1957	2157	1507	167.0	62.8	73.0	47.0	85.0	27.3	24.8	5.7	97.5	22.1
Ford — Consul	1956	2504	1703	169.9	68.7	81.0	53.5	88.0	32.6	25.7	6.0	114.2	21.9
Volvo PV-444	1946	2140	1580	177.0	62.5	76.8	48.7	90.0	30.4	29.9	4.4	122.0	17.5
Average (1400-2000 cc)		2267										109.4	20.5
Vauxhall (Velox — Cresta)	1957	2590	2262	177.7	68.5	84.5	53.5	88.5	32.9	25.7	5.8	114.2	22.6
Ford (Zephyr — Zodiac)	1956	2691	2553	178.5	68.8	85.2	53.5	88.0	32.7	25.7	6.0	114.2	23.6
Opel Kapitan	1955	2670	2473	186.4	69.3	89.6	53.2	94.0	34.6	27.0	6.1	120.0	22.2
Mercedes — 220 S	1956	2920	2195	187.0	68.5	89.0	53.5	95.0	35.2	28.8	7.0	128.3	22.8
Renault Fregate	1951	2866	2141	185.0	67.7	87.0	55.0	90.0	34.4	25.8	6.2	118.0	24.2
Standard — Vanguard	1956	2688	2088	172.0	67.5	80.6	52.0	90.0	32.5	25.0	5.5	108.4	24.8
Holden — Fe-215	1956	2350	2172	176.0	66.9	81.5	52.0	93.0	33.6	27.0	5.9	117.0	20.0
Average (2000-2500 cc)		2682										117.2	22.9
Chevrolet (6 Cyl)	1958	3622	3860	209.1	77.7	113.0	56.4	95.0	37.2	27.8	7.3	131.0	27.7

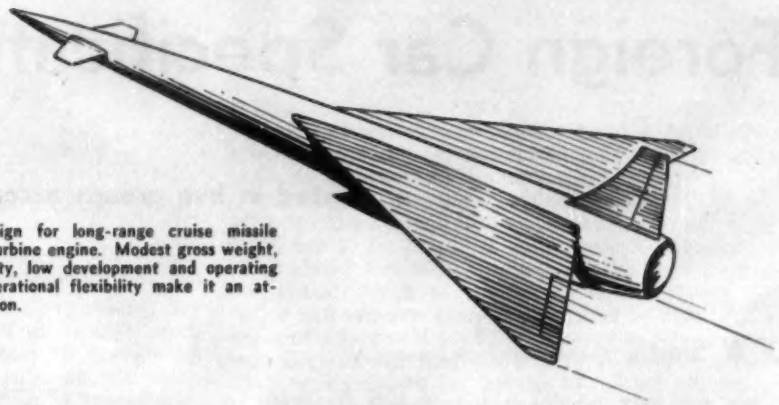


Fig. 1 — Design for long-range cruise missile powered by turbine engine. Modest gross weight, basic simplicity, low development and operating cost, and operational flexibility make it an attractive weapon.

Why Not Turbine-Powered

Based on paper by

R. E. Neitzel and M. A. Zipkin

General Electric Co.

DON'T overlook the possibilities of turbine-powered missiles for the future. Advances in turbine engines could make possible air-breathing Mach 4 missile systems having marked operational and economic advantages.

Here are some possible future supersonic missile systems to consider:

1. Long-Range Cruise Missile — Surface-to-surface missiles of intercontinental range could well complement the ICBM as a weapon system class. The flexible trajectory of this type of missile would force a potential enemy to make a big investment in defense efforts quite different from any antiballistic missile system they might contemplate. It may be developed for carrying intercontinental weapons as fully or partially recoverable reconnaissance systems, or as long-rang decoys to deceive and dissipate the enemy defense against manned bomber attacks.

Missiles of this type will be characterized by high aerodynamic efficiency, a very high ratio of fuel weight to gross weight, and an engine sized primarily for adequate acceleration thrust at low supersonic Mach numbers. For cruise at Mach 4 the engine will be operated at reduced reheat setting to

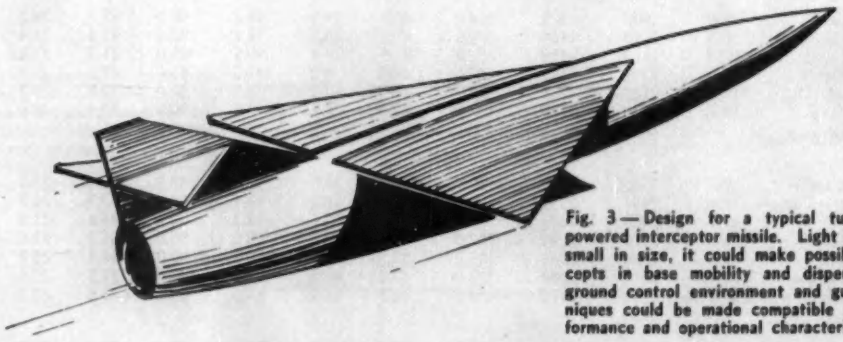


Fig. 3 — Design for a typical turbine-engine-powered interceptor missile. Light in weight and small in size, it could make possible new concepts in base mobility and dispersal, provided ground control environment and guidance techniques could be made compatible with its performance and operational characteristics.

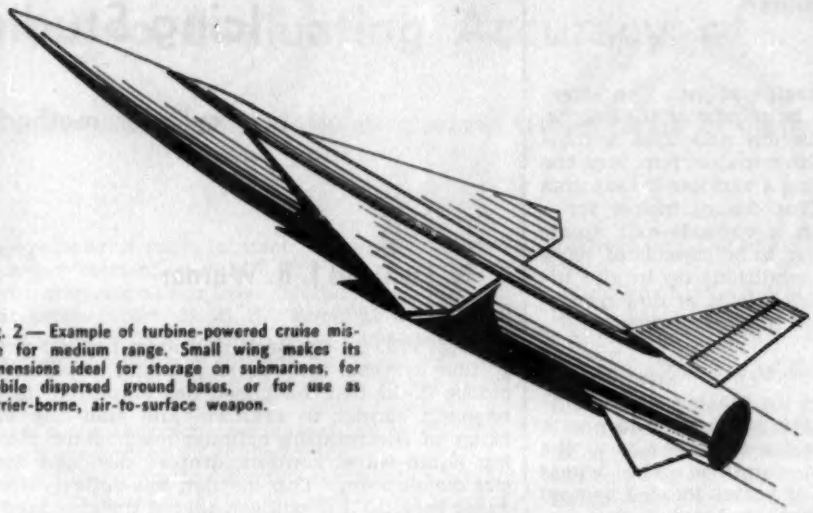


Fig. 2 — Example of turbine-powered cruise missile for medium range. Small wing makes its dimensions ideal for storage on submarines, for mobile dispersed ground bases, or for use as carrier-borne, air-to-surface weapon.

Missiles?

obtain minimum specific fuel consumption at the altitude for best range.

Such a missile is exampled in Fig. 1. It has the following assumed characteristics:

Cruise L/D — 7
Ratio of fuel weight to gross weight — 0.61
Thrust to weight ratio at launching — 0.4
Specific engine weight — 0.18
Ratio of airframe and fixed equipment to gross weight — 0.24
Payload (warhead and gudiance) — 5000 lb
Gross weight — 65,000 lb
Range — 5000 nautical miles

2. Medium-Range Cruise Missile — This would be a smaller missile of zero length to be launched from ship, submarine, or dispersed mobile launcher in the tactical theater. It would be designed for a striking radius of 1000 nautical miles. Its desirable features would be the high flexibility of its trajectory, the choice of high or low target approach, and chance to hit the target area from any direction.

With appropriate changes made in the guidance system, it could be launched from subsonic or supersonic aircraft in flight. The striking range would then rise to about 1500 nautical miles because the need to go through a complete acceleration and climb phase would be obviated.

Characteristics of this missile would be moderately good aerodynamic efficiency, relatively low fuel load, high payload, and a fairly high thrust to weight ratio made possible by the light-weight, small-size engine. Typical design parameters of this missile (shown in Fig. 2) would be:

Cruise L/D — 5
Ratio of fuel weight to gross weight — 0.32
Thrust to weight ratio at launching — 0.70
Specific engine weight — 0.13
Ratio of airframe and fixed equipment to gross weight — 0.25
Payload — 1700 lb
Gross weight — 5000 lb
Range — 1000 nautical miles

3. Interceptor Missile — Dramatic advancements in specific engine weight and high-speed capability of missile turbojets in small frame size has made possible this third class of missile. Interceptor missiles having very high combat performance could be developed for air defense against supersonic manned bombers and other missiles. Compared to current area defense missiles, they will have a fraction of the gross weight and vastly superior base mobility and dispersal characteristics. They can be deployed from mobile land bases or launched from shipboard, and their operational range would be limited by radar range alone.

Fig. 3 shows a missile of this class. Typical design parameters would be:

Cruise L/D — 3.5
Ratio of fuel weight to gross weight — 0.24
Thrust to weight ratio at launching — 1.4
Ratio of airframe and fixed equipment to gross weight — 0.26
Payload (warhead and guidance) — 800 lb
Gross weight — 2500 lb
Combat range — 400 nautical miles

High-Mach Turbine Engines

Turbojet and turbojet-ramjet (dual cycle) engines are typical of the several self-accelerating, air-breathing engines which can be used for missiles in the flight regime of Mach 4.

Here is a description of a typical turbojet for Mach 4 flight: It is a low-pressure-ratio, full-reheat engine designed for supersonic flight without regard for subsonic performance. It comprises a multistage compressor driven by a single-stage turbine with a

Why Not Turbine-Powered Missiles?

continued

relatively moderate inlet temperature. The afterburner, which represents a large part of the engine, is conventional in construction and uses a film-cooled liner. The nozzle, also a major item, is of the ejector or bypass type, having a variable throat area and a fixed exit area. This design makes for a lighter engine weight than a variable-exit nozzle area. The engine is designed to be capable of 100% physical rpm at all flight conditions up to and including Mach 4 and will pass a level of flow consistent with the corrected speed of the compressor.

Design for a Turbojet-Ramjet

A typical turbojet-ramjet for Mach 4 flight comprises an engine of moderate pressure ratio plus a bypass system which provides air directly to the afterburner at high Mach numbers. The bypass system consists of a series of valves located around the periphery. At approximately Mach 3, this engine goes through a transition from turbojet to ramjet operation. At this condition, the bypass valves open and the gas generator is shut down. Air is then supplied by the bypass system directly to the afterburner.

The conventional turbojet is lighter and simpler than the turbojet-ramjet. Moreover, it need have only a single mode of operation throughout its complete flight range. The turbomachinery is in the way at high Mach cruise conditions and this is a disadvantage. The resultant pressure losses decrease the specific thrust and increase the specific fuel consumption a small but measurable amount. Moreover, the turbojet is limited to lower Mach numbers than the dual-cycle engine.

The principal feature of the turbojet-ramjet is its bypassing of the turbomachinery when it no longer contributes to engine output. This minimizes pressure losses and the performance (specific thrust and sfc) is slightly improved. Total thrust at high Mach numbers can be much greater than for the basic engine because of the potential for greatly increased airflow. Bypassing also increases the Mach number potential of the engine, since there are problems associated with turbomachinery which can limit flight speed in the straight turbojet engine.

The turbojet-ramjet engine has two disadvantages. The bypass valves and ducting increase the engine weight in the order of 10%. And the transition from turbojet to ramjet operation involves additional complication in the engine control and perhaps the inlet control.

High Mach Engines on Horizon

Both of the foregoing engines can be developed for Mach 4 use by a reasonable extension of existing technology. Moreover, the turbojet-ramjet engine can be developed to use gas generators designed for Mach 3 flight. The choice will depend upon the particular application and the engine availability.

To Order Paper No. 48A . . .
. . . on which this article is based, turn to page 5

Icing Studies

rotating cylinder method of

Based on talk by

C. H. Fish and J. B. Werner

Lockheed Aircraft Corp.

PROMPTED by the need to pretest new ice protection systems and develop better existing ones before flight test, Lockheed has employed its icing research tunnel to evaluate and find the useful range of the rotating cylinder method for measuring liquid-water content, droplet size, and droplet size distribution. This method was actively investigated because it is still considered the standard one.

When the liquid-water content of a tunnel cloud, as measured by this instrument, was compared with the known water input (as measured by flow rotameters), a lower value was invariably obtained, with the percentage difference being greater at the higher tunnel temperatures and/or liquid-water contents. This was attributed initially to freeze-out (formation of ice crystals rather than supercooled water droplets) or the presence of a large percentage of very small drops that do not impinge upon the cylinders. However, there is little reason to assume ice crystals in a mixed cloud will not be caught upon the cylinders or that an abnormally large amount of small drops exists.

Reason for Discrepancy

The discrepancy is now believed due to the so-called "Ludlam effect" on the rotating cylinders. This is the liberation of the heat of fusion of the water droplets as they freeze and, under appropriate thermodynamic conditions, enough heat is liberated to prevent all of the water from freezing.

From studies of the factors affecting the surface conditions on a cylinder (such as cylinder diameter, ambient temperature, ambient pressure, airspeed around cylinder, water droplet diameter, and liquid-water content) curves of the form shown in Figs. 1 and 2 have been obtained. These show, as a function of ambient temperature and airspeed, the cloud liquid-water content for a given droplet diameter and cylinder diameter which will just result in a cylinder surface temperature of 32 F with all impinging water freezing. This is the maximum cloud liquid-water content collectable on the cylinder without "blow-off" of the excess water occurring; hence it is the "saturation" value, and the use of rotating cylinders in clouds with liquid-water contents above this value will result in erroneous readings.

Range of Accuracy

The curve in Figs. 1 and 2 show the allowable liquid-water content to be very low at the ambient

Lead to Evaluating Accuracy of . . .

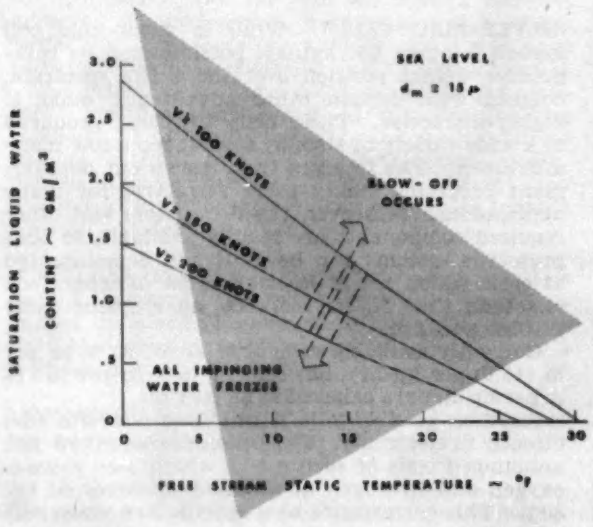
measuring water content in air stream. Useful range of method determined.

temperatures of most interest. The maximum liquid-water content is only 0.10 g per cu m for 15-micron droplets at sea level, 200 knots, and an ambient temperature of 25 F. Even at an ambient temperature of 15 F it is barely 0.5 g per cu m. The allowable liquid-water content increases with altitude, but it is still only 0.16 g per cu m for 15 microns, 25 knots, and 20,000 ft. Under these circumstances a significant percentage of the catch (25%) is being evaporated off the cylinders.

The critical cylinder diameter (that which has the smallest "saturation" value of liquid-water content) is not the smallest of the cylinders in the normal multicylinder set (⅛-in. diameter) but is an intermediate size, the value of which depends upon airspeed.

Curves of per cent water frozen as a function of liquid-water content for a tunnel speed of 150 knots, a tunnel temperature of 15 F, and 15- and 35-micron droplets, have been computed and compared to the ratio of LWC measured by the rotating cylinder method to the water input as measured by a rotameter. The agreement in the data is adequate to permit the conclusion that for these conditions the rotating cylinders are in error in measuring the liquid-water content and by an amount which is approximately equal to the water content which is not frozen on the cylinders.

Fig. 1 — Cloud liquid-water content for a given droplet diameter and ⅛-in. cylinder diameter (as a function of ambient temperature and airspeed) which will just result in a cylinder surface temperature of 32 F with all impinging water freezing. This is a maximum cloud liquid-water content which can be collected on the cylinder without "blow-off" of the excess water occurring.



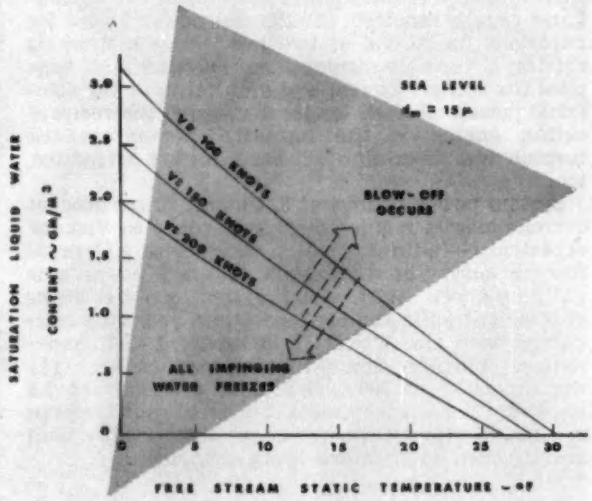


Fig. 2 — Calculated liquid-water content for a 1¼-in. diameter cylinder. The use of rotating cylinders in clouds with liquid-water contents above this value will result in erroneous readings.

Energy Sources for

Missile Auxiliary Power

Based on paper by

E. I. Brown and R. W. McJones

Vickers, Inc.

FOR missile auxiliary power systems in the capacities usually required, the lightest power source for durations up to one or two minutes is a flywheel driving a variable-displacement pump which supplies the control system and an alternator for electrical power. For all longer durations, the reciprocating engine is the lightest. Monopropellant turbine and silver-zinc cell batteries are attractive, too.

System power ratings of 5, 10, and 20-hp bracket current missile requirements, according to Vickers' experience — a finding which agrees with a General Electric survey of the missile auxiliary power unit (APU) market. Within each system, a power brake of 50% hydraulic and 50% electric is generally consistent with the Vickers and reported G.E. experience. Further detailed considerations are: (1) the provision of 100% hydraulic overload for 1.0 sec and, (2) the acceptance of a 50-50 split between a-c and d-c electric power where batteries are used and d-c can be provided more efficiently.

comparison of systems

The results of the system studies are presented graphically in Fig. 1. Here, system specific weight (lb per hp) is used rather than absolute system weight to permit ready evaluation of scale effects. Interpolated specific weights may be used for calculating the weights of intermedates size systems. General conclusions can be drawn from these three charts, as follows:

FLYWHEEL — A flywheel system is the lightest available for durations up to 1 min. and is competitive with most currently available systems up to 6 min. The reliability, simplicity, low development cost, and excellent storage characteristics, coupled with excellent weight characteristics, recommend the flywheel for further consideration.

RECIPROCATING ENGINES — Where ambient air is available for combustion and cooling, the conventional reciprocating engine is the lightest powerplant for all but the very shortest durations, where the flywheel takes over. Its superiority has long been recognized for automotive and aircraft applications, where duration is measured in hours. And it is surprising to find these same engines unchallenged down to durations of a minute or two.

A reciprocating engine using self-contained fuel and oxidizer may be developed within the next few years. Such an engine probably will use only liquids, hence it will not require a compression stroke and will yield more power per unit piston displacement than is currently available. On the other hand, it may require rather elaborate injection equipment.

SILVER-ZINC CELLS — While a silver-zinc cell system is never the lightest possible one, its competitive weight position over the entire spectrum, coupled with certain other advantages, make it highly attractive. These cells are being produced in a wide variety of sizes by several reputable manufacturers. The freedom from drawn out development programs makes them attractive for many applications. Moreover, the d-c motors and other required components are readily available, so that prototype systems can be built and demonstrated at costs which are at least an order of magnitude less than that of, for instance, an ethylene oxide turbine package.

Currently available cells offer about 50 w-hr per lb (15 lb per hp-hr), but cells of 75 w-hr per lb (10 lb per hp-hr) are believed to be possible.

Another possibility is a cell that converts fuel directly to electricity. The Union Carbide Corp. has announced tests of such a cell, which uses gaseous oxygen and hydrogen at a stated efficiency of 65–80%. This corresponds to a specific fuel consump-

Systems

tion of about 0.5 lb per hp-hr. The primary limitation of this cell is its larger weight per watt-hour.

While cells using various forms of nuclear energy are under development, the handicap of the moment is believed to be the large fixed weight per unit output. Out of the USSR comes the highly significant published comment: "Existing radioactive sources of current are still very ineffective. They can be used only for supplying airplane accessories."

HOT GAS SUPPLIES — The hot gas supply to servo valves and actuators generally is heavier than a battery-powered system and it is slightly heavier than a monopropellant turbine system in the 10- and 20-hp sizes.

In addition to the weight disadvantage, there are two other fundamental limitations: (1) to provide a-c power, two complete power systems would be required, involving development problems. This in turn would require maintaining two types of prime mover — the hot gas system for flight controls and perhaps a battery inverter or turbine-drive system for a-c power, (2) the hot gas system has not achieved a development comparable with either battery of turbine-driven systems but it will have to before adequate reliability can be demonstrated.

The primary reason for considering hot gas actuators has been the threat of high-temperature problems in hydraulic systems. As yet the threat has not materialized due to the development of successful high-temperature hydraulic systems and the surprisingly adequate thermal lag of missile hydraulic systems in actual flight.

ETHYLENE OXIDE TURBINE — The relatively poor weight showing of this system and the known difficulties in handling monopropellant fuels suggests that the great development effort necessary is a poor investment.

COMPRESSED GAS SYSTEMS — These systems are too heavy.

To Order Paper No. 48D . . .
. . . on which this article is based, turn to page 5.

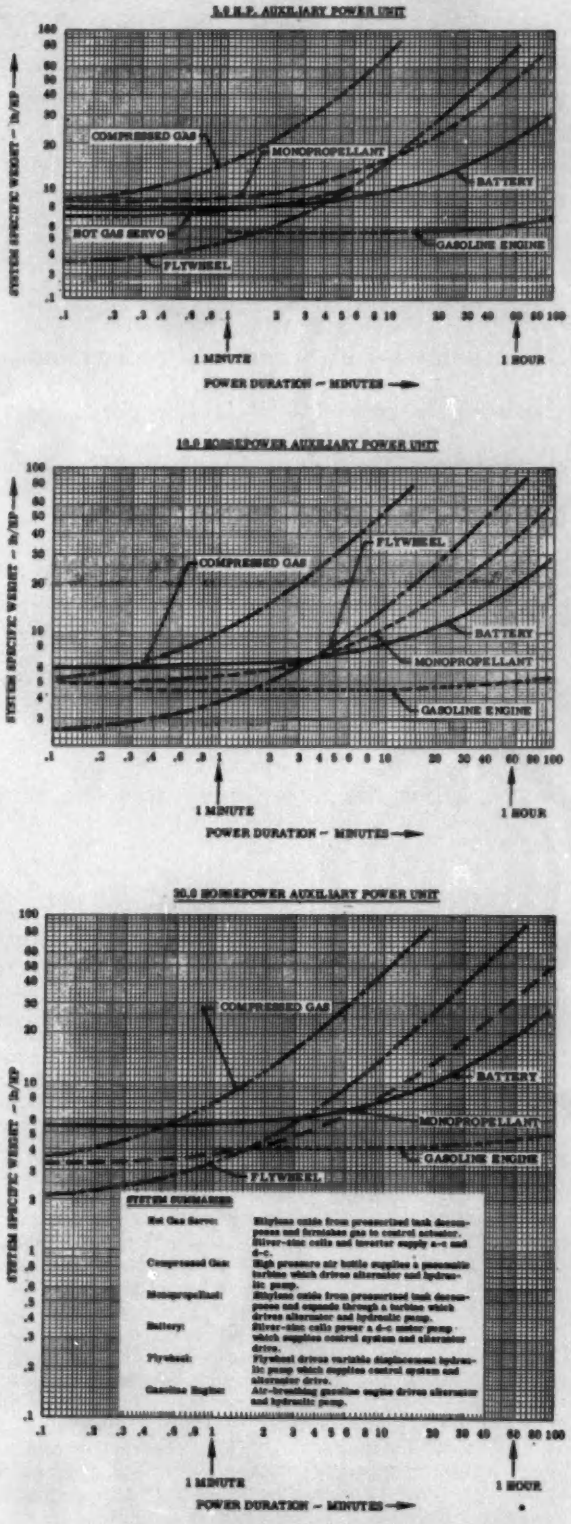


Fig. 1 — Various APU types compared against each of three typical system requirements. 50% hydraulic (provision for 100% overload for 1 sec); 50% electric (all a-c or one-half a-c, one-half d-c, as convenient).

Optimum Mileage for a Jet Transport . . .

. . . usually results from a specific cruise-climb flight path. This is the conclusion drawn from experience with military jet transports.

Based on paper by

W. M. Stout and R. E. Sliney, Jr.
Aircraft Laboratory, Wright Air Development Center

THIS optimum-mileage path is a constant-airspeed/constant-power program which is very simple to fly. All that is required is to establish the initial altitude and airspeed for the gross weight at start of cruise. Holding the airspeed the aircraft will then be allowed to gain altitude of its own accord as fuel consumption lowers the weight.

Analytically this path may be determined by plotting, for parameters of gross weight, the maximum mile per unit of fuel for each altitude, as indicated in Fig. 1. The envelope of the peaks of these curves thus formed represents the altitude path as weight is reduced.

Since the cruise-climb flight path is a climb, a correction is required to the mileage for the added power required to climb. In general this approximates a reduction of 1% in mileage. If traffic control will permit, a cruise-climb path is the optimum to use for best range and ease of operation.

Variations from optimum airspeeds and altitude impose rather impressive losses in range. These items are directly within the pilot's ability to control, and every effort should be made to maintain the preplanned flight path and airspeeds. Figs. 2 and 3 illustrate the penalty of such deviation. If an altitude loss does occur the pilot should not climb back using climb power; rather he should hold airspeed and power constant and permit the aircraft to cruise-climb back to the desired altitude.

To Order Paper No. 388 . . .
. . . on which this article is based, turn to page 5.

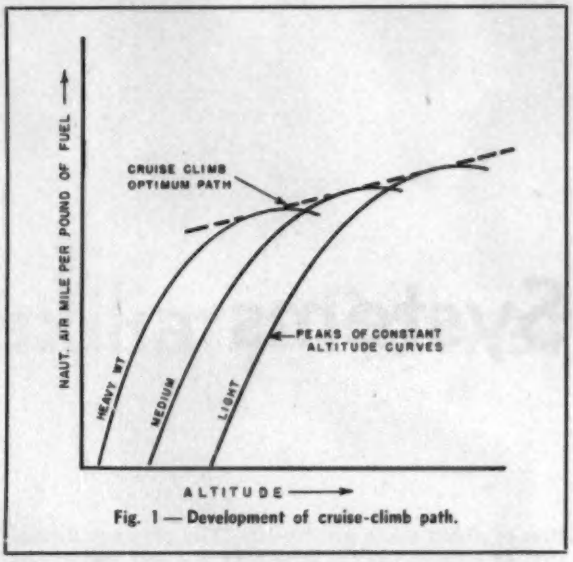


Fig. 1 — Development of cruise-climb path.

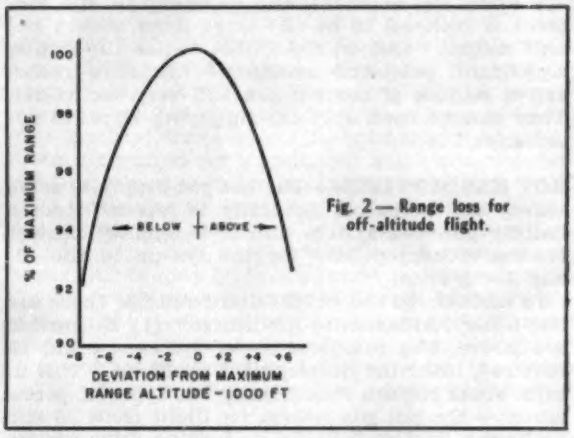


Fig. 2 — Range loss for off-altitude flight.

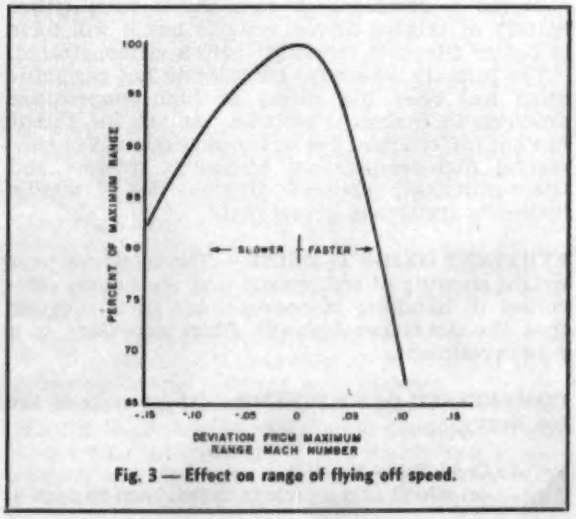


Fig. 3 — Effect on range of flying off speed.

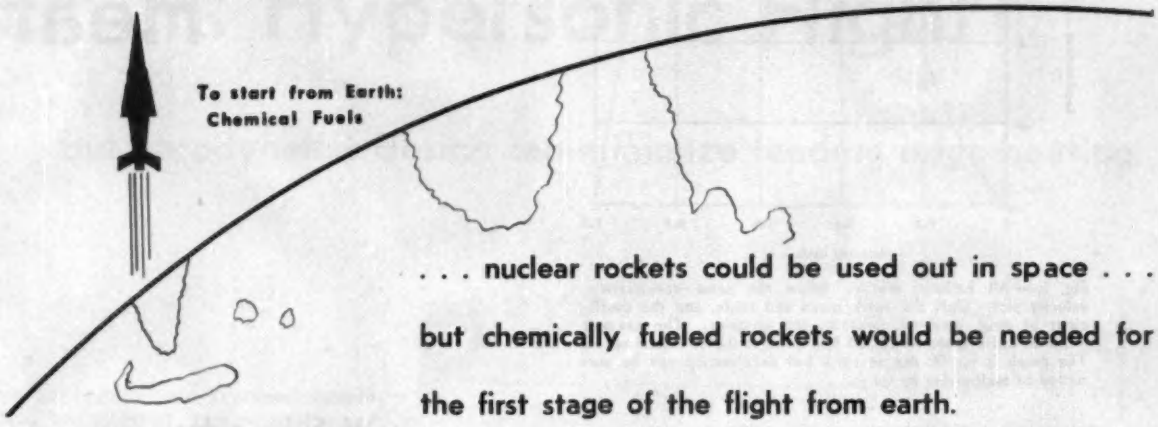
For a Trip to the Moon . . .

A feature of the

SAE Nuclear Energy Advisory Committee

In Space: Nuclear Fuels

Coming Back: Nuclear Fuels



. . . nuclear rockets could be used out in space . . . but chemically fueled rockets would be needed for the first stage of the flight from earth.

Reported by

Dr. C. R. Lewis

chairman, SAE Nuclear Energy Advisory Committee

NEWS that the AEC expects to test components of a proposed nuclear rocket system this summer has stimulated us to compare the potentialities of nuclear rockets with those of the already successful chemically fueled rockets. Such studies indicate that both kinds of rockets will be needed to send vehicles to the moon or other parts of space:

- Chemically fueled rockets will get the vehicle off the ground and out of the atmosphere.
- Nuclear rockets will take over when the vehicle reaches the region where the earth's gravitational force is substantially less than it is at the surface. (Nuclear rockets would also probably be adapted to land the vehicle on the moon and take off from it, since the moon has no atmosphere and the thrust required to overcome the local gravitational field — 1/6th that of earth's — is comparatively small.)

The chemically fueled rockets will be used for the first lap of the flight because they are capable of exerting the high thrusts and high accelerations necessary to break away from the earth's surface and carry the vehicle through the high air resistance of the lower atmosphere.

A thrust equal to the vehicle's weight is needed at the surface just to maintain the vehicle at rest relative to the surface. Energy expended to maintain this thrust does not appear as useful work in lifting the vehicle. Neither does the thrust used to overcome air resistance of the atmosphere.

For the next stage, though, where air resistance is negligible and gravity greatly reduced, it would seem that some form of nuclear-propelled rocket would provide the best answer. The main reason is that it can generate the low values of thrust for long periods of time that will be needed for the rest of the journey through space.

A one-gravity feel is the normal environment for humans, and a continuing acceleration at one gravity would be desirable to maintain the familiar environment for the crew of a space vehicle. Such moderate accelerations applied for long periods of time will result in very high velocities. For example, a continuing acceleration of one gravity for 24 hr will result in a velocity of 527 miles per sec. For comparison, the velocity of present satellites is only 5.0 miles per sec. Kinetic energy equivalent to an initial velocity of 7.0 miles per sec must be supplied to a vehicle to overcome the gravitational attraction of the earth. This is the so-called escape velocity, or the velocity that an object initially at rest infinitely far from the earth would acquire in falling to the earth's surface. Escape velocity from the moon is 1.5 miles per sec, from Mars it is 3.3 miles per sec, and from Venus it is 6.5 miles per sec.

When nuclear-propelled rockets are designed as outlined here, propellant to payload ratios of the order of 10 may be achieved. For chemical fuels, the ratio is 1000 or more.

A number of arrangements have been proposed for using nuclear powerplants to provide thrust for rocket propulsion. Some of them have been described in the paper, "Nuclear Rocket Propulsion — a Survey of Proposed Concepts," by T. F. Nagey, presented at SAE Summer Meeting, June 9, 1958.

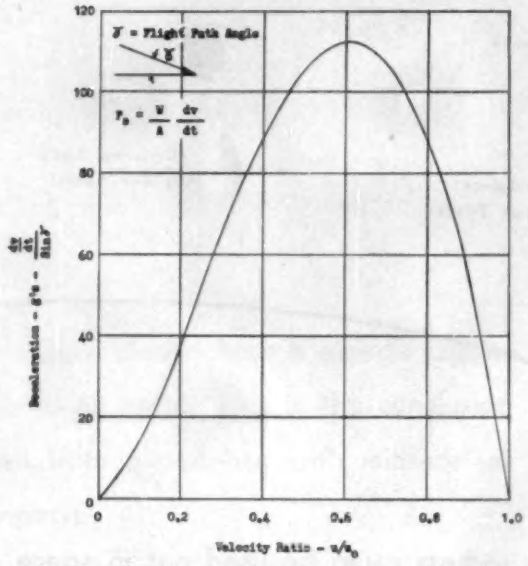


Fig. 1. — All ballistic missiles follow the same deceleration-velocity plot. Only the entry speed and angle, and the coefficient of drag, assumed constant, are variables. The example is for an entry speed of 20,000 fps. This is 0.8 of orbital speed. The graph is for 90-deg re-entry but deceleration can be corrected by multiplying by sin γ.

Heat

Based on paper by

W. F. Radcliffe

Convair Astronautics

HYPERSONIC flight through the atmosphere brings massive heating problems. Two conditions where these problems occur are the re-entry of a missile and the high-speed gliding missile. The first is a short-duration, high-rate-of-temperature-increase example and the second a constant-temperature case.

All re-entering missiles have a similar type of trajectory, due to the exponential character of the atmosphere. The only conditions that must be known are the velocity and angle of re-entry. The drag coefficient is assumed constant and known.

Under these conditions the velocity ratio-deceleration plot in Fig. 1 holds true for the example shown. The effective pressure causing the deceleration can be calculated, and from this the heat transfer is determined. Fig. 2 gives the heat transfer at the one foot station of a pointed cone for the example shown in Fig. 1. The major heating effect occurs shortly after the missile enters the atmosphere. After that the velocity of the missile is decreasing faster than the density of the air is increasing in so far as the heat-

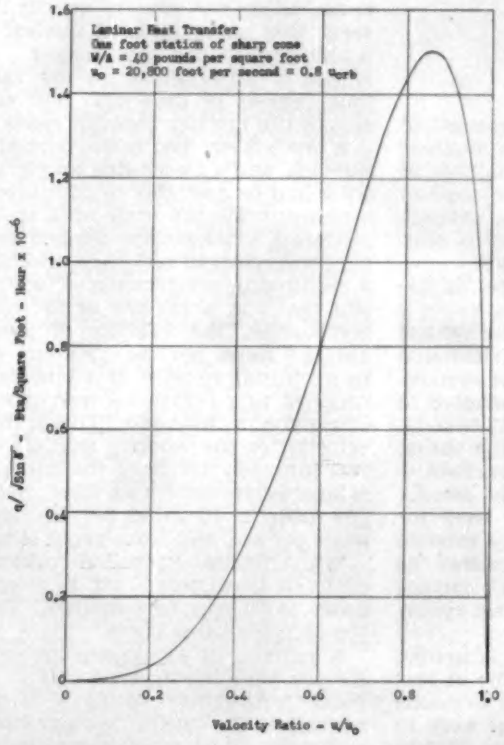

Laminar Heat Transfer
One foot station of sharp cone
W/A = 40 pounds per square foot
u0 = 20,800 foot per second = 0.8 ucrb
Velocity Ratio - u/u0

Fig. 2 — Heat transfer can be calculated directly from Fig. 1. The maximum transfer occurs at 0.85 velocity ratio for the cone.

Limits Hypersonic Flight

. . . but aerodynamic design can minimize leading edge heating.

ing of the missile is concerned. Heat transfer at the nose of the cone would be much greater than at the one-foot station. This leads to the design of blunt nose shapes for high-speed aircraft and missiles.

How to Keep the Nose Cool

Conventional means of removing heat from a sharp leading edge are difficult. These include radiation, cooling systems, and heat sinks. The extremely high heat transfer rate at the front of a flat plate demonstrates this (see Fig. 3). Putting a cylindrical shape on the front of the plate not only cuts the transfer rate but gives room to cool the surface. The dotted lines in Fig. 3 are for different leading edge radii and angles of attack of the plate.

A 30–50% increase in range of a glide missile could be realized by effecitve use of the high lift-to-drag ratio of wings. However, the wing loading will have to be low if high temperatures are to be avoided. Fig. 4 shows wing loading as related to temperature at the one-foot station of a plate. A 40 psf or lower loading will probably be required to keep the temperature below 2300 F.

To Order Paper No. 39A . . .
on which this article is based, see p. 5.

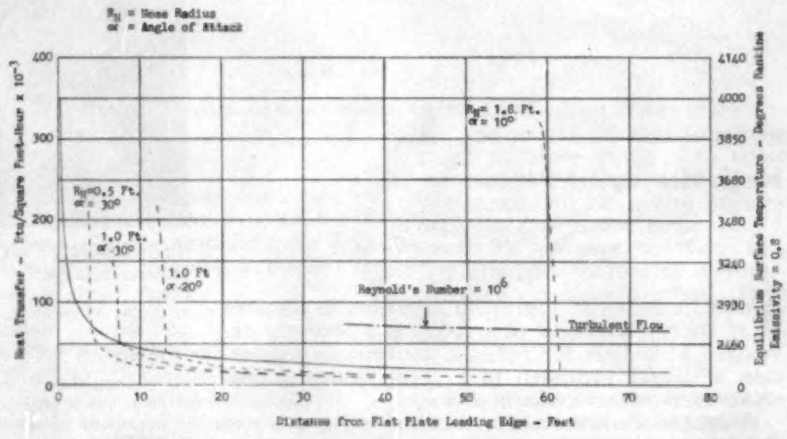


Fig. 3 — A flat plate with a wing loading of 40 psf traveling in a 20,800 fps glide path has a high equilibrium temperature at the leading edge. This can be reduced by rounding the nose and increasing the angle of attack, as shown by the dotted lines.

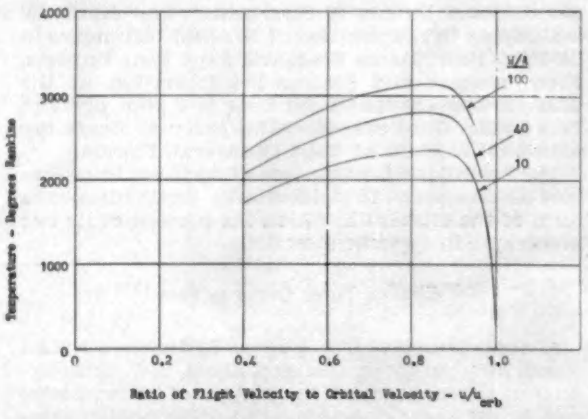


Fig. 4 — Temperature required to balance air heat transfer by missile radiation drops with wing loading (W/A). An emmisivity of 0.8 is assumed.

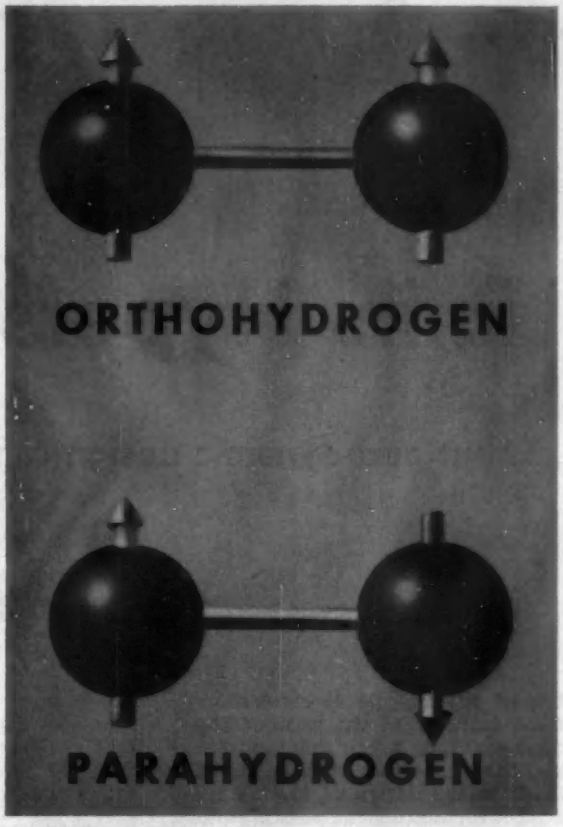
Hydrogen As A Flight Fuel . . .

. . . may become feasible because of a new liquefaction technique that yields a more stable form.

Based on talk by

Hugh Harvey,
Shell Oil Co.

(Presented at meetings of SAE Northern California Section and SAE Northwest Section)



HYDROGEN'S TWO FORMS are parahydrogen (below) and orthohydrogen (above). At room temperature and pressure, hydrogen is a gaseous mixture of about 25% para and about 75% ortho forms. At its boiling temperature, -423 F, hydrogen is about 99.8% para molecules and only 0.2% ortho molecules under equilibrium conditions. Transformation of the ortho form to para releases heat. Conventional liquefaction process changes hydrogen from gas to liquid much faster than its ortho molecules transform to para molecules. The result is that the heat is emitted while the transformation continues for 30 days or so, emitting enough heat to evaporate two thirds of the liquid. New liquefaction process yields parahydrogen directly and greatly lessens evaporation-loss problem.

BASIS for renewed interest in hydrogen as a source of energy for flight propulsion is a recently developed technique for reliable, continuous production of liquid hydrogen in a form suffering only small evaporation losses in storage.

Hydrogen contains more available energy per unit weight than any other substance. But it must be liquefied to make it attractive on a unit volume basis.

The new liquefaction technique was worked out at the National Bureau of Standards. The Air Force is studying the application of the NBS techniques in its Baby Bear, Mama Bear, and Papa Bear Projects. From meager and scattered information in the press, it appears that Baby Bear is a pilot plant in Painesville, Ohio and that the parental Bears are scaled-up versions at Cape Canaveral, Florida.

The technique involves use of hydrous ferric oxides as catalysts. It yields mostly parahydrogen, a form of the element in which the protons of its two atoms spin in opposite directions.

Chilling Turns Ortho to Para

At room temperatures, gaseous hydrogen contains about 25% parahydrogen and about 75% orthohydrogen, a form in which the protons of its two atoms spin in the same direction. But at its boiling temperature, –423 F, hydrogen contains 99.8% of the para form and only 0.2% of the ortho form. Conventional liquefaction techniques yield mostly the ortho form, which gradually transforms to the para with the emission of heat. It takes about a month for conventionally liquefied hydrogen to complete the molecular rearrangement. Either the heat must be absorbed by refrigeration equipment during that period, or at the end of 30 days, 64% of the original liquid will have boiled away.

All that is needed to store liquefied high-para-content hydrogen produced by the NBS technique is a well-insulated storage vessel to protect the liquid from heat on the outside. Containers now used allow only about 130 of 1300 gal to boil away over 10 days, thanks to their highly efficient evacuated powder insulation.

Trends in 1958 Truck Design

Walter G. Patton
Staff Representative, SAE Truck and Bus Activity Committee (and Engineering Editor, SAE Journal)

Written at the request of the SAE Truck and Bus Activity Committee, whose members cooperated in supplying material for this article.

THIS summary of recent advances in truck design and engineering, has been prepared at the request of and with the cooperation of the SAE Truck and Bus Activity Committee. It is a companion piece to a similar engineering story on passenger cars appearing in the SAE Journal, December 1957.

The first part of the article lists truck engineering and design highlights for 1958. This is followed by a brief summary of the outstanding features of 1958 models. Following this is a detailed discussion of engineering changes reported recently by the truck manufacturers.

Part II of this study, called "Looking Forward," will appear in a forthcoming issue. As suggested by the title, future powerplants and other phases of future truck design and motor transport economics will be discussed.

Contents of Article

Design Highlights ..... Page 90
Engines ..... Page 93
Transmissions and Drive Lines ..... Page 96
Chassis and Frame ..... Page 100
Cooling Systems ..... Page 101
Tractor-Trailer Combinations ..... Page 101
Styling and Sheet-Metal Engineering ..... Page 103

A WELL-known Detroit truck engineer who predicted that the truck industry would soon enter the fastest-moving period of development in its entire history may have been too conservative. There is evidence to show this fast-changing period of development has already arrived. Here are a few of the significant truck engineering advances announced during the past 12–18 months:

- At least 10 new gasoline or diesel engines were introduced.
- The truck industry got its first air suspension systems.
- A new off-beat body style, combining both passenger-car and truck buyer appeal, is now available. One new model combines a 6-passenger cab with a pickup body.
- The trend toward more compact tractor-trailer units has been stepped up. A West Coast development, the Dromedary, permits the use of a preloaded truck body as well as a preloaded trailer.
- A number of changes in brake design, including water-cooled brakes, have been suggested as a solution to the growing truck braking problem.
- Four-headlight designs were offered, practically across the board on certain models, by truck manufacturers.
- The number of new truck body styles introduced in 1958 equaled,

Trends in 1958 Truck Design

. . . continued

if it did not surpass, almost any previous year.

- Several new transmissions, both automatic and semi-automatic, are now available for truck use, including new heavy-duty and light-weight units. Flexibility and efficiency of the new transmissions represent a substantial engineering advance for the industry.
- A 1 to 1 ratio of curb weight to payload in a standard, light-duty commercial vehicle has been achieved by a U. S. truck manufacturer.
- Light-weight components and weight saving packages for trucks are gaining acceptance.

While not a complete list, these highlights obviously reflect the tremendous amount of engineering activity now going on in the truck industry.

The 1958 Trucks . . .

. . . represent important engineering advances by the motor transportation industry. New engines, new transmissions, new suspensions, and new styling are featured in this year's models.

Autocar Division, White Motor Co., has recently introduced a new line of lightweight trucks and tractors engineered to carry maximum payload with minimum weight. They are reported to save up to 25% in tractor weight as compared to standard-weight vehicles and as much as 1800 lb under light-weight vehicles currently available.

Autocar's new A series includes a full range of tractors and trucks, 4- and 6-wheel models. All are of the axle-forward type with a 30-in. dimension from front-of-bumper to center-of-front axle. Diesel power ranges from 180 to 262 hp.

The company has also built a number of trucks designed especially for use in South American oil fields. Among the engineering features of these special vehicles are 3-axle drive, 300-hp supercharged Cummins diesel engines, power steering, and air starting. The 254-in. wheelbase vehicles are equipped with 1200/24 20-ply tires. Double channel all-bolted frames are used, as well as inside fish plates for extra support.

Brockway Motor Trucks, Division of Mack Trucks, Inc., has recently introduced a new short, bumper-to-back-of-cab tractor.

The tractor has a 137½-in. wheelbase and a CA dimension of 69 in. BA dimension is 27½ in. The new tractor can be used in combination with a 35-ft trailer and still be within a 45-ft overall limit. The gtw ratings go as high as 65,000 lb.

Tractors in the new series can be gasoline-, LPG-, or diesel-engine powered. Turbocharged diesels are also available.

Transmission options include 4, 5, 8, and 10 speeds forward. Single-speed spiral-bevel, 2-speed, and double-reduction rear axles are offered.

Front fenders swing away for better engine accessibility.

Brockway is now supplying diesel engines of 175, 180, and 190 hp, supplementing the standard Brockway-Continental gasoline engines ranging from 125 to 225 hp. Recently introduced is a revision of the 513 cu in. 200-hp gasoline engine.

A new 348 cu in. V-8 engine tops the list of new features incorporated in the 1958 model Chevrolet trucks. Other new items in the Chevrolet line are:

- 12 new models.
- Dual headlamps on all models.
- New styling.
- Expanded use of full air brakes on heavy-duty models.
- Expanded use of air-over-hydraulic brakes on medium-duty models.

Three new Fleetside pickup models were introduced during the 1958 model year.

New models for 1958 include nine new medium-duty, cab-chassis models. Six of these new models, including three low cab forwards, have 72-in. cab-to-axle dimensions.

New forward-control vehicles combine the Chevrolet forward control chassis with all-steel van bodies. The new models are designated, "Step-Van."

Diamond T's new line of trucks includes the Model 922, which combines light weight with ability to operate in the heavy-duty field, and the 923, designed to carry lesser loads at lowest cost. Diamond T has also recently announced a new Tilt-cab 923C diesel.

All of these new models are diesel powered. Single-axle tractors of the 922 series are rated at 65,000 lb gcw; tandem-axle models are rated at 76,000 lb. Model 923 tractor is rated at 60,000 with standard rear axle and 65,000 with oversize rear axle. The Diamond T Tilt-cab diesels carry the same rating. These models are also available as 6-wheelers.

A "Lightweight Package" is offered which reduces weight 700 lb or more.

New Full Vision cabs and adjustable seats have been designed into the latest Diamond T models.

The Diamond T Tilt-cab series is powered by the new Cummins NH-180 diesel. This engine is a smaller displacement engine than the Cummins NHB600, which it duplicates in many respects. Most major components are the same. Exceptions are smaller size cylinder sleeves and pistons and a lower capacity fuel pump.

Dual intake and exhaust valves, 4½-in. diameter 7-bearing crankshaft, stellite valve seat inserts, and the Cummins PT fuel injection system are specified. The new NH engine is naturally aspirated.

A new 314.61 cu in. double-rocker-shaft engine, increased gvw and gcw ratings for many models, improved transmissions, and better braking systems have been incorporated in 1958 Dodge trucks.

Developing 207 gross hp at 4400 rpm, this new 314.61 cu in. engine was introduced to meet the grow-

ing requirements of medium-tonnage models.

The most recent addition to the Dodge forward-control family — the Minivan, door-to-door delivery model introduced in 1957 — is 169 in. from bumper to bumper. The Dodge LoadFlite pushbutton transmission is standard equipment.

The 1958 Dodge Town Wagon, a low-cost station wagon, is offered with a 120-hp 6-cyl engine, or with the 204-hp V-8 engine.

A new Dodge 4-wheel-drive model, the W300, is rated at 10,000 lb gvw. A choice of V-8 or 6-cyl engine is offered. Pushbutton automatic transmission is available on V-8 models. The W300 is available as a pickup, stake, platform, chassis and cab, or chassis cowl model for special bodies.

Three new engines with 401, 477, and 534 cu in. displacement for models rated at 30,000-lb gvw and up head the list of Ford truck model changes for 1958.

In addition to fresh, new styling, including the use of dual headlamps on all conventional and tilt-cab models, Ford is offering improved transmissions, heavier axles, and a new 40-amp generator (on 750, 800, and 900 series).

Ford's heavy-duty trucks have new, heavier transmissions. Medium-duty models offer an automatic transmission as optional equipment.

In the heavy-duty range, fuel tank selection is increased and new electric fuel pumps minimize the possibility of vapor lock.

A new 8-speed transmission is available for heavy-duty and extra-heavy-duty trucks.

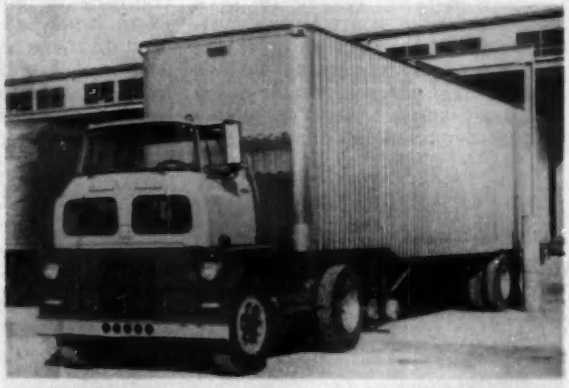
GMC Truck & Coach Division has two new models for 1958, including a 16,000-lb gvw package-delivery and a light-weight conventional air suspension tractor. A new lightweight GMC diesel D860 highway tractor with advanced engineering design fits jobs of 55,000 lb and up.

The company introduced a new 336 cu in. V-8 engine in 1958 as well as a fully automatic transmission. Important styling changes were also introduced this year.

International Harvester has recently introduced two entirely new vehicles. The tilt-cab Sightliner is designed to carry maximum payload in minimum length. Length from front bumper to back-of-cab is only 48 in.

Outstanding feature of this new model is a triple windshield, including two windows at about

GMC D860 diesel highway tractor is one of lightest in its weight class, thanks to aluminum construction.



INTERNATIONAL Sightliner has V-8 engine, short BBC, and outstanding visibility.

AUTOCAR'S new planetary-gear-drive rear-axle 25-ton dump truck has an adjustable steering wheel. Box section frame is all-welded construction.

INTERNATIONAL Travelette combines attractive styling and 6-passenger cab capacity in light-duty truck. Pickup body is 6 ft long.

Trends in 1958 Truck Design

. . .continued

floor level, designed to permit the driver to see the ground immediately in front of the vehicle. This adds 632 sq in. to the regular 1076 windshield area. Restricted close-up visibility has been a limitation of the COE design.

The new model is 31 in. shorter than current COE models.

The Sightliner is designed to place increased weight on the front axle; also, there is space for more payload than earlier designs. The new models are expected to fill a particular need where cargos are bulky and overall length limitations have limited the earning power of trucks moving over the highway.

IHC's A-Line Travelette is a passenger-type commercial vehicle designed to carry an optimum number of passengers as well as substantial cargo. Built on a standard chassis, the Travelette has a 6-passenger custom cab. There are two doors on the curb side and a single door on the street side of the new vehicle.

Powerplant is the IHC Black Diamond 240 high-torque 6-cyl engine. Black Diamond 264 is also available.

The new model is offered on four 129-in. wheelbase chassis and as 4-wheel drive. Overall length is 210 in.

Introduced during mid-1957, International Harvester's A-line models range from 4200 to 33,000 lb gvw.

Styling features include sweep-around windshields, high-level cowl ventilation, and 5-point outrigger cab mountings.

All are powered with a new series of Black Diamond, valve-in-head engines. There are five gasoline engine sizes; four use LP gas.

New A-line vehicles include a deluxe streamlined pickup for business or family use, and a Travel-all utility station wagon. Driver comfort is emphasized by the 65-in. wide cab that will accommodate three persons comfortably. The seat is 8 in. wider than on previous models. The sweep-around windshield provides 1181 sq in. of unobstructed visibility.

Three new diesel truck-tractor models with short BBC (90 in. to rear top of cab) have also been introduced by International Harvester for 1958.

Included in the newest Kenworth models are three new COE's, tilting and nontilting, a new conventional and the recently introduced CFE dromedary trucks designed particularly for West Coast service.

Among the outstanding features of the new dromedary models are (1) two front axles, both of which steer, (2) front and rear air suspension, (3) midship mounting of the horizontal engine, (4) extensive use of aluminum, (5) ability to change in seconds a preloaded box for the cargo box on the truck, (6) greatly increased payload capacity and increased cube.

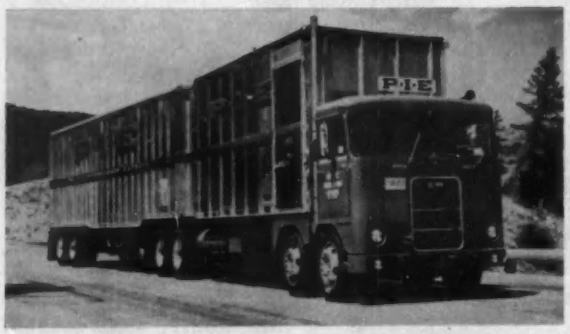
The new Kenworth tilt cab goes forward at a 55-deg angle. When tilting is completed a safety hook catches automatically and the cab is unable to move. As the cab returns to driving position, the safety hook resets itself automatically. It is built in three lengths — 54 in., 73 in. sleeper, and 86 in. sleeper.

Kenworth's new short cab COE 54 in. is designed primarily for use with 25-ft doubles. It is a non-sleeper, permitting maximum loading space. Distance from the front bumper to back of cab is 54 in.

Reo Division, White Motor Co., is again offering a wide selection of vehicles for the medium- and heavy-duty fields, as well as specialized equipment for both the domestic and foreign markets.

Newest additions to the line are the C series tandems featuring gasoline, LPG, and diesel engines,

MACK cab-forward models are available as 4- or 6-wheel trucks or tractors.



KENWORTH truck designed with aid of Pacific Intermountain Express has two front axles, both of which steer. Cargo box behind cab can be preloaded and lifted on and off in a few seconds.

WILLY'S famous Jeep is now a cab-over-engine forward-control truck. Redesign of cab and change in weight distribution have made possible a ratio of about 1 lb of payload for each pound of curb weight.

contour fenders that are divorced from the cab, center hinged hood, and curved one-piece windshield. Front-of-bumper to back-of-cab dimension is 101.5 in.

Reo's C tandem line includes five gasoline-powered 6×4's, one gasoline 6×6, and two 6×4 diesel units. The C series ranges from 35,000 to 52,000-lb gvw.

The C-436, designed especially for the ready mix industry, permits front-axle loading of 14,000 lb and up to 32,000 lb legal loading on the rear axles.

Mack's 1958 line of trucks is topped by new cab-forward models. The new models are available as 4- or 6-wheel trucks or tractors and are reported to be the first cab-forward trucks capable of accommodating a diesel engine over 200 hp.

Wrap-around windshield, extra-wide doors, and dual headlights are featured. Other features include short wheelbase, wide front-axle tread, and a widened frame in front permitting exceptionally short turning radius. Linkage-type power steering is available on all models.

Designated as the N-Group, the new line is divided into two series: the 4- series is rated at 28,000-lb gvw; the 60 series has maximum gvw of 30,000 lb.

For 1958 Mack is also offering a heavy-duty tractor cab with BBC of 89 in. The new design is 13 in. shorter than Mack's conventional model. Additional space is provided for the driver by tilting the engine slightly to the right.

A wide range of engines, models, and gross vehicle weights is included in Studebaker's 1958 line of Transtar trucks. Very recently, the company announced the Studebaker Scotsman will be available as a half-ton pickup. The Scotsman is rated at 4800-lb gvw. Length of the pickup body is 6½ ft. The 6-cyl engine is rated at 92 hp.

For 1958, Studebaker will have five models in the 2-ton medium- and heavy-duty series. Power steering, power brakes, and automatic transmissions are available on most light-duty models.

Recently introduced to meet the growing requirements for high-cube trailers is the new White 3400TD COE powered by a 180-hp Cummins diesel engine. The new model features a power tilt cab, engine accessibility from the ground level, short BBC, and an extra-large radiator mounted in the rear of the cab. The new model is available as single-axle, tandem, or pusher model tractor.

White is also offering a new 2000 series in the medium-duty field powered by a 6-cyl gasoline engine. Three models are offered, including a truck, tractor, and tandem. The gvw rating of these vehicles is 22,000–23,000 lb on the trucks and 35,000–41,000 on the tandem. Wheelbases range from 150 to 185 in.

Willys Motors' latest models, the Jeep FC 150 and 170, have attained a goal established a number of years ago by Willys engineers: a versatile commercial vehicle in which the ratio of curb weight of the vehicle to payload is 1 to 1. This is believed to be the lowest ratio in the U. S. truck industry today for a standard light-duty commercial vehicle.

Design changes have played an important part in this achievement.

Major contributing factor is the cab-forward design. Frame and chassis are, essentially, the same as on the Willys Jeep and station wagon. There have been no major substitutions of light metals for steel.

In addition to the familiar pickup or platform bodies, the Willys FC-150 can now use dump truck or service truck bodies.

The Willys FC-150 with 81-in. wheelbase permits a cargo body of 74½ in.

The larger, more powerful Jeep FC-170 has a rating of 7000 lb. With a 103.4-in. wheelbase, the ratio of cargo length to wheelbase is exceptionally high. Payload is approximately 30% greater than the Jeep FC-150. Pickup or stake bodies can be 9 ft long.

Visibility is outstanding in both vehicles, which have 2747 sq in. of safety glass area, including a wrap-around windshield of 1200 sq in.

Engineering changes now under test are expected to extend the gvw rating of Willys vehicles. The company will continue to supply a large number of special-purpose vehicles to a wide range of users including the Armed Services, police, fire and safety, road and park maintenance, and public utilities. More than 90% of Willys vehicles being built are 4-wheel drive.

Engines . . .

. . . represent major engineering advancements in 1958. . . . Truck producers are adding to the number of lines they are producing. Many engineers feel this is only the beginning of a long period of development that will see truck engines up to 500 hp for some applications.

Outstanding features of the new Chevrolet engine include (1) completely machined combustion chamber of radically new design located within the cylinder bore, (2) top face of block machined at a 16-deg angle, to a plane perpendicular to the bore, (3) center location of spark plugs, and (4) staggered valve arrangement, permitting the use of larger valves.

Aluminum peaked-roof pistons are positioned with one dome surface parallel to the plane of the flat head and the other at 32 deg. This results in a thin, squish-and-quench area in half of the cylinder and a wedge-shaped combustion chamber in the other. Extreme turbulence and short flame travel are characteristic of this arrangement.

Other features of the new Chevrolet heavy-duty V-8 engine include the use of large, sodium-cooled stellite-faced exhaust valves, replaceable silichrome inserts and rotators of the rotocoil type. Intake valve faces are aluminum coated. Both intake and exhaust valve stems are chrome-plated.

To form the combustion chamber, the piston has a peaked head, with top faces also at 16 deg from the perpendicular. Thus, one face of the piston is parallel to the flat cylinder head and the other face

Trends in 1958 Truck Design

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is at a 32-deg angle to the head. This angle produces the main combustion volume.

To achieve the shape and volume desired, a portion of the top of the bore is machined out. Thus, the combustion chamber is formed entirely of machined surfaces, permitting precise control of the compression ratio.

The large flat surface of the cylinder head permits the use of large valves and also makes it possible for intake and exhaust valves to be offset from each other. Location of the valves in a flat surface is said to eliminate much of the shrouding effect present when valves are placed in a hollow or cove.

The shorter length of the new engine makes it possible to relocate the fan for increased clearance and reduced noise.

A new, wide-outlet water pump provides uniform, full-cycle cylinder bore cooling. Water is directed at an angle to all cylinder bores, permitting freer movement of the coolant.

Aimed particularly at the medium-duty trucking field, Cummins' recently introduced NH-180 diesel of 180 hp, is a development from the well-known 200–335-hp Cummins engines giving exceptional fuel economy. The NH-220 crankshaft, block, connecting rod, piston pins, bearings, valves, and cylinder heads have all been incorporated in the NH-180.

Use of cylinder heads providing two intake and two exhaust valves per cylinder permits good breathing for high and efficient power output. The engine has exceptionally low exhaust temperature.

Replaceable, wet-type cylinder liners are used.

The Cummins NH-180 has a total projected main bearing area of 61.15 sq in. Open combustion chamber, dual intake and exhaust valves, roller-type cam followers, and simple flyweight-type governor are used.

The NH-180 Cummins diesel engine has seven main gearings, 4½ in. in diameter. Exhaust valve seats are stellite inserts. Water pump capacity is 73 gpm at 2100 rpm.

A choice of three diesel engines is offered for Diamond T Model 922. The 743 cu in. HRFB engine is rated at 190 bhp and has a maximum torque rating of 575 lb. Bore and stroke are 5⅛ × 6 in. The 4-valve NH-220 develops 220 hp at 2100 rpm. The turbosupercharged NTO-6 is rated at 262 bhp at 2100 rpm.

For the 923 series the new NH-180 672 cu in. engine provides 180 bhp at 2100 rpm. Maximum torque output is 450 lb-ft. The Diamond T Tilt-cab 923C is powered by the Cummins NH-180 diesel.

Low-tonnage Dodge models for 1958 include a 204-hp, 314.61 cu in. single-rocker-shaft engine; medium-tonnage models include a new heavy-duty 314.61 cu in. single-rocker-shaft V-8 engine. Heavy-tonnage models are available with 354.06 cu in. V-8 powerplants with up to 234 hp.

A new 314.61 cu in. V-8 engine with a double-rocker shaft is now available for all medium-tonnage Dodge models, 400–600, and is standard on the C600 COE.

The horsepower of all Dodge medium- and high-tonnage V-8 models has been increased.

During 1958 Ford introduced three new super-duty over-square, short-stroke V-8's with ratings up to 277 hp. The new Ford 534 engines are standard on Ford F-1100 and C-1100 trucks and optional on models T-850 and T-950 tandems.

The stress-relieved, deep block is a Y-type, giving main bearings a full 240-deg support. A forged-steel crankshaft is used.

The new Ford engines have the combustion area entirely within the block. Combustion chambers are fully machined for greater accuracy. Face of the cylinder head is flat machined at 90 deg. The new wedge-shaped combustion chambers and Turbulence Top piston heads give improved fuel-air turbulence for increased power and reduction in engine deposits.

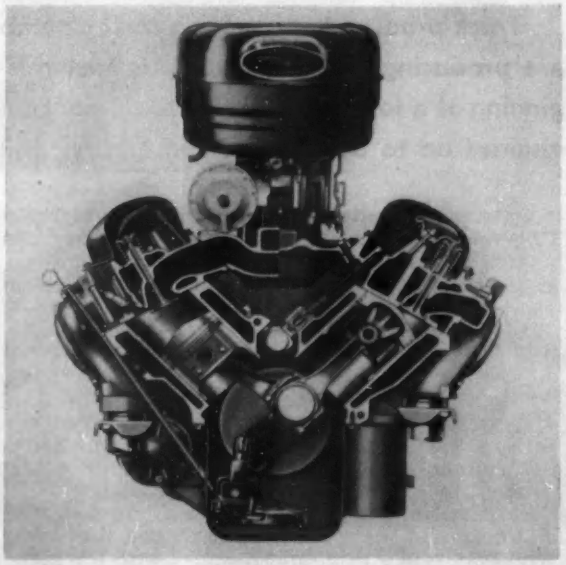
Ford is also offering its 5-speed transmission and special axle combinations to fit the precise need of a specific operation.

General Motors Detroit Diesel Engine Division recently introduced four new diesels: the 71-T and 71-E series. Both 4-cyl and 6-cyl engines are available from 26,000-lb to 60,000-lb gvw, and up.

The E series has four exhaust valves per cylinder. Fuel injectors have a new spray tip that is said to atomize fuel more completely.

Cylinder liner air inlet area has been increased 38% to facilitate cooler piston operation. A new fire-ring or top compression ring is reported to add to piston life and improve engine power. A new high-capacity, low-speed blower is used.

The 71-T series is turbocharged. Available on all truck models



COMBUSTION CHAMBER of Chevrolet 348 cu in. engine is practically all in cylinder block instead of in head. Entire combustion chamber is machined.

through the 500 series, the new 336 GMC truck V-8 engine has a unit-cast chromium alloy iron cylinder block and upper crankcase. Its drop forged steel crankshaft weighs 64.5 lb.

Tin-plated cam-ground aluminum-alloy pistons are specified. All pistons are held to a weight tolerance of ⅛ oz. All three piston rings are above the piston pin.

Inlet valves are made of aluminum-coated chromium-nickel steel for 100-8 through 250-8 series trucks; silichrome XB steel is used for 350-8 through W 500 models. Exhaust valves are aluminum-coated XCR steel or silichrome X10 steel with hard facing.

GMC's new model D 860 developing 189 hp at 1800 rpm and standard axles give the new tractor ratings of 30,000-lb gvw and 60,000 lb.

In addition to new heavy-duty bearings, 1958 Willys Jeep engine rings use 100% chrome-plated rings.

The new Jeep 6-226 L-Head engine develops 190 ft-lb of torque at 1400 rpm. Alloy iron is used in the block. Stellite valves are specified.

For 1958, White is offering a new 180-hp Cummins diesel with smaller bore and less displacement than previous diesel models.

To offer its users minimum BBC, White continues to tilt-mount its gasoline engines at 10 deg and its diesel engines at 20 deg in the 9000 series models.

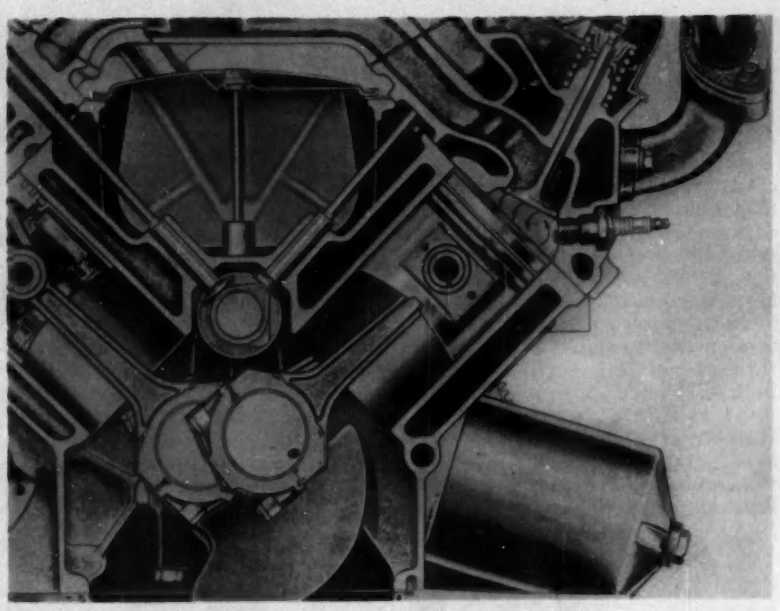
Water circulation is improved in the 1958 models. A contributing factor here is an improved method of aeration by which air is bled out of the system. Control of water temperatures within very narrow limits has also been improved, it is reported.

The 1958 Mack turbocharged diesel features an exhaust connection using a ring-type joint instead of a bracket. The elbow is fastened directly to the center of the exhaust manifold.

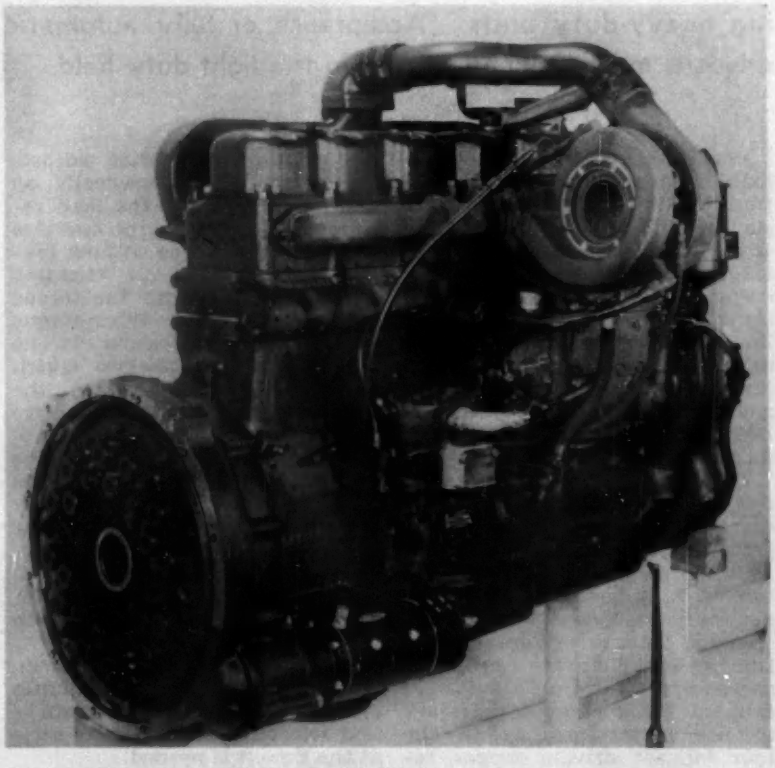
In Kenworth's new CFE dromedary trucks, the 250-hp turbosupercharged diesel engine is mounted horizontally, about midway beneath the frame. The engine is easily accessible for maintenance.

In its COE models, Kenworth has moved the engine forward, putting additional weight on the front axle. This also permits shorter wheelbases.

Reo engineering features in-



HIGH-TURBULENCE COMBUSTION CHAMBER of Ford truck engine improves engine efficiency and gives full power and economy.



TURBOCHARGER EXHAUST CONNECTION of Mack diesel uses ring-type joint instead of bracket.

Trends in 1958 Truck Design

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clude an oil temperature stabilizer that holds oil temperature within 35 deg (F) of engine coolant, sodium-filled exhaust valves, full-flow and bypass oil filtration, and high-velocity cooling.

Reo also has a companion line of four 6-cyl gasoline engines and three 6-cyl LPG engines. These high-efficiency powerplants, like Reo V-8 engines, continue to feature replaceable wet-sleeve cylinders.

Studebaker-Packard is offering four engines, including a 259 cu in., 170-hp V-8, and a 239 cu in., 182-hp V-8. With 4-barrel carburetion horsepower is increased to 178 and 192. Compression ratio for all truck engines for 1958 is 7.5/1.

A premium-engine package is being offered by Studebaker, making available many of the heavy-duty features of the 289 cu in. engine in the 245 cu in. 6-cyl engine or the 259 cu in. V-8. The package includes heavy-duty inlet and exhaust valves, heavy-duty exhaust-valve springs, chrome-plated, top compression piston rings. On the 259 cu in. engine, the premium package includes heavy-duty aluminum timing gear, and heavy-duty connecting rod bearings and crankshaft bearings.

Transmission and Drive Line . . .

. . engineers have introduced a number of new semi-automatic and fully automatic transmissions for trucks, including heavy-duty units. Acceptance of fully automatic drives is moving ahead rapidly in the light-duty field.

Regardless of the transmission-axle combinations selected, the trend for the trucking industry is strongly in the direction of faster trips, lighter-weight and shorter-length truck-trailer combinations, easier driving, and higher operating efficiency. Transmission, drive line, and axle manufacturers are meeting these conditions with a number of new developments, including new fully automatic transmissions, semi-automatic transmissions, and 2-speed axles.

The Allison Torqmatic heavy-duty transmission was developed specifically to meet the needs of truck manufacturers.

Basically, the Torqmatic is a torque converter in series with a planetary gear train. The unit is operated through a hydraulic control system. There are six forward speeds and four forward driving ranges. These make unnecessary the use of wide range axles. The four forward driving ranges, reverse, and neutral positions are controlled by a selector lever.

The torque converter adjusts output torque automatically as well as speed to fit the load requirements. The engine operates at its governed speed without lugging or stalling. All standing starts are made with the torque converter operating. When torque converter multiplication is no longer needed, a lockup clutch locks the engine through the transmission for mechanical drive in any range.

Advantages claimed for the Torqmatic in addition to shockless shifts include (1) uniform gear tooth loading to insure long gear life, (2) disc-type clutches hydraulically operated and oil cooled, and requiring no adjustment for wear, (3) gear shifts within each range entirely automatic.

The hydraulic control system, then, automatically coordinates load, speed, grade, and terrain — and selects the proper gear ratio at the time it is needed.

A built-in hydraulic retarder assists in braking, enabling the driver to reduce vehicle speed without using the service brakes. The retarder, controlled by a separate floor pedal, multiplies engine braking as much as six times.

A throttle over-control permits holding the transmission in one gear unless truck speed decreases enough to require a downshift.

SAE power take-off is provided on each side of the transmission. No separate take-off is required.

To insure optimum efficiency and economy, transmission shift points are matched to power peak of the engine.

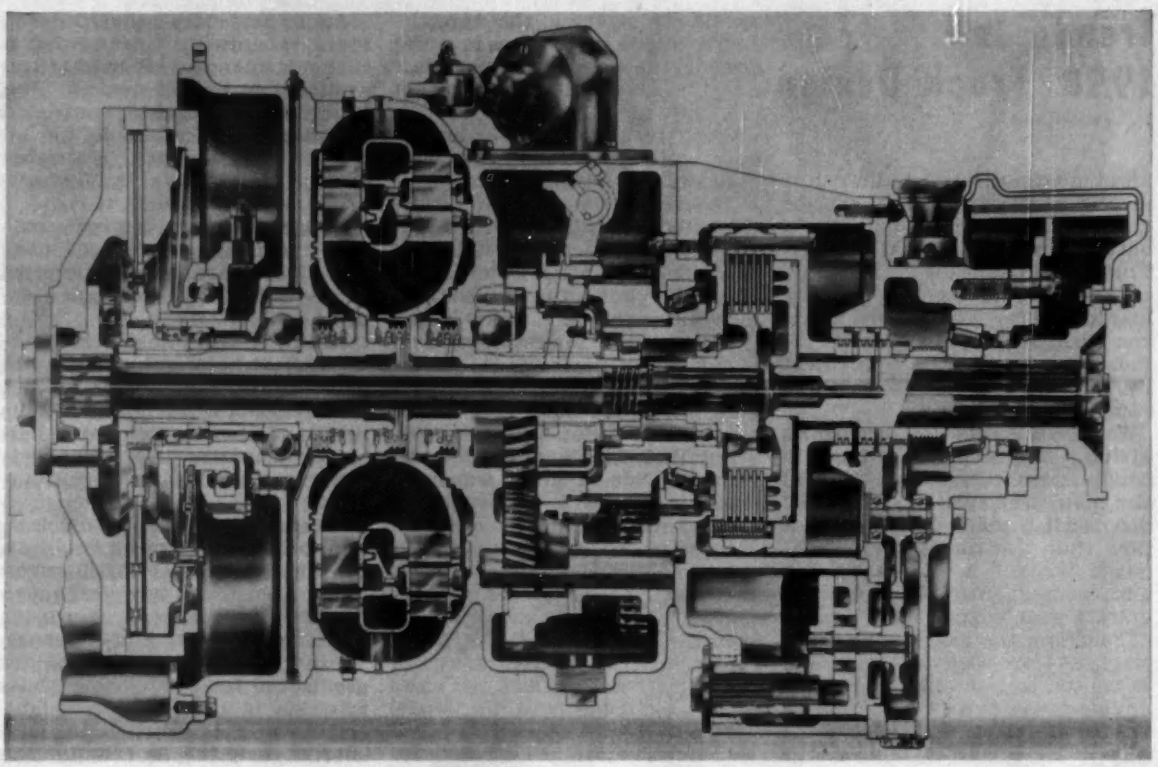
Recently introduced for commercial use are Dana Corp.'s 12-speed and Turbo-Matic transmissions. Model 8125 Synchro-Master 12 was developed to provide a multiple-speed, heavy-duty transmission that is shorter and lighter than existing units. The new Spicer unit is 12 in. shorter and 200 lb lighter than any previous multiple speed transmission having equal capacity, it is claimed.

Advantages of the new unit include (1) ability to give sufficient gear reduction and spread to handle various road conditions with the need for an auxiliary transmission or a 2-speed axle, (2) ability to provide the close steps needed to maintain engine speeds at maximum rpm for optimum fuel economy and to avoid engine lugging.

The Synchro-Master 12 has blocker-type synchronizers in all speeds, forward and reverse. All six low range ratios are available in reverse. There are standard 6-bolt SAE power takeoff apertures on each side. Steps between ratios are equally spaced. Bearing retainer inserts in all case bores are replaceable.

The 183 Turbo-Matic transmission combines a hydraulic torque converter with a forward and reverse gear arrangement and a straight-through drive. Advantages claimed for this arrangement include high normal efficiency and ability to deliver a smooth flow of power and rapid acceleration under variable load conditions. Operating advantages include minimum torsional vibration and shock, improved operating economy, and reduced maintenance.

Using fluid drive, the torque ratio is 5.5/1. Depending on the application, this is graduated down to direct drive or lockout. A hydraulically operated disc clutch



SPICER TURBO-MATIC TRANSMISSION is fully automatic and combines hydraulic torque converter with forward and reverse gear arrangement and straight-through drive. Shifting is accomplished by hydraulically actuating a multiple-disc clutch. Torque ratio is 5.5/1. Depending on the application, this is graduated down to direct drive or lockout.

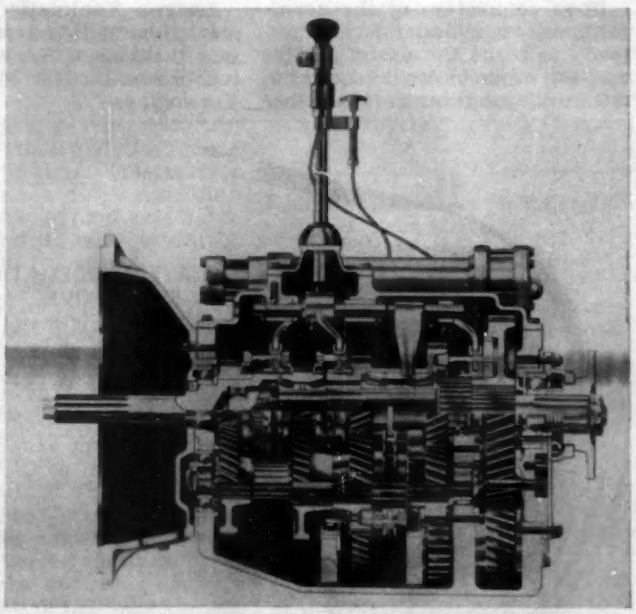
insures smooth shifts under all load conditions.

Spicer's Powr-Lok transmission is now being used on a number of trucks of different make. The Powr-Lok unit delivers many times the torque of the slipping wheel to the driving wheel. It provides a torque ratio between the axle shafts which is based on the amount of friction in the differential and the amount of load being applied to the differential.

Offered originally in the medium-duty truck field, Powr-Lok is finding increasing use in light-duty, commercial vehicles. Units for larger axle sizes are expected to become available this year.

Clark Equipment Co. has recently introduced a 10-speed transmission of semi-automatic type known as the Stepmatic. It is available in two sizes.

The new transmission has an automatic shiftable direct and underdrive auxiliary section. This is attached to the front of a 5-speed manually shifted synchro-



SPICER SYNCHRO-MASTER 12-SPEED TRANSMISSION is a light-weight unit for heavy trucks. It is 12 in. shorter and 200 lb lighter than previous multiple-speed units of comparable capacity.

Trends in 1958 Truck Design

. . . continued

nized transmission. A downshift in the auxiliary section can be made at any time by touching a button on the gearshift lever. This is an instantaneous shift and can be made without throttle manipulation. The upshift is accomplished by merely lifting the foot from the throttle momentarily, until the shift is automatically completed.

Either upshifts or downshifts giving a 28% step can be made in combination with manual shifts of the main transmission. The fast downshift is made possible by the fact that the underdrive is engaged through a one-way clutch and, consequently, does not require a gear engagement.

Touching the control button on the shift lever does two things: (1) it causes an interruption of the engine power and (2) it permits a preloaded spring to disengage the direct drive and complete the downshift. As soon as this shift is completed, engine power is reestablished, causing engine speed to increase until it picks up the underdrive through the one-way clutch.

Upon completion of the downshift, an air cylinder is charged, ready to make the upshift. This upshift cannot occur, however, until a torque reversal takes place by simply relaxing the throttle. As the engine speed drops it comes down to the auxiliary output shaft speed, permitting completion of the shift.

Chevrolet's Powermatic heavy-duty automatic transmission is basically the Allison design.

The regular 3-speed transmission used with Chevrolet V-8 engines now has increased durability in reverse operation. Turboglide and Powerglide units are modified for greater torque capacity.

To permit a selection of axles giving better performance or increased economy with the V-8 engine, a new, low-ratio rear axle is available in ½-ton trucks.

For 1958, Diamond T 922 is offering a wide range of transmissions, including a 4-speed main, 5-speed main, 5-speed main with 3-speed or 4-speed auxiliary, 10-speed Roadranger, and the new 12-speed Synchro-Master. Aluminum cases are available for weight reduction.

Similarly, a wide range of choices of transmissions and axles is now available with the Model 923 and Tilt-cab series.

In its 923 model, Diamond T for 1958 employs a 15-in. single-plate dry-disc clutch as standard. A 14-in., 2-plate clutch with a lining area of 423 sq in. is optional, and standard with oversize transmissions.

Dodge's Torqmatic fully automatic heavy-duty transmission is now available on conventional and school bus models 500–700 using V-8 engines.

An all new extra heavy-duty, 5-speed synchro-shift transmission is standard on the 900 models and available on the 800 models. The LoadFlite pushbutton controlled transmission is available for all low-tonnage models, Forward-Control models, and 4-wheel-drives, except W300M.

Dodge has a new 4-speed auxiliary transmission for its 900 models. There are two underdrive ratios, direct drive, and one overdrive ratio.

Dodge is also offering its Full-Traction differential on the rear axles of D100 and W100 models, which automatically splits the driving force so the wheel best able to do so can "dig in" when adverse road conditions are encountered.

An example of a highly efficient, semi-automatic transmission is the Fuller R-96 RoadRanger. Table 1 illustrates how gear ratios can be closely spaced to provide optimum flexibility and efficiency.

Other advantages claimed for multispeed semi-automatic transmissions include lighter weight, better weight distribution, and shorter length. By eliminating the second drive shaft required with an auxiliary unit, vibration and the possibility of misalignment are minimized.

Another recent development by Fuller (and others) is a power-declutching device. The Fuller De-Clutch unit permits all shifts in forward motion without depressing the clutch pedal. The clutch pedal is used only for standing starts.

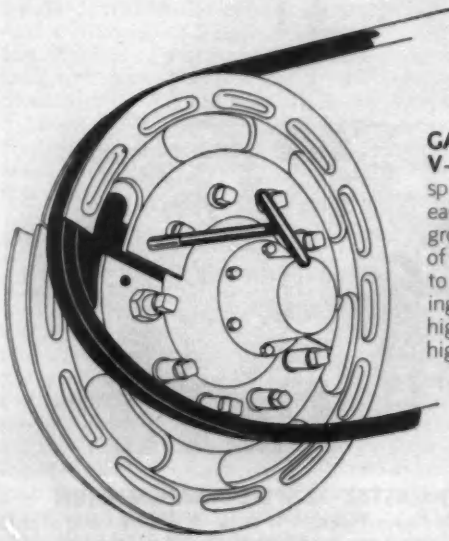
A recent drive line development is the Gates Tandematic V-belt drive, a device for getting power to a dead axle. It has two interesting features:

1. A split pulley is used so the belt may be installed with high initial tension.
2. A special belt is specified that will handle the tensions and load requirements to be met.

For 20-in. wheels, pulley diameter is 24 in. For the larger 22-in. spoke wheels, a 26-in. pulley is recommended.

Essentially, the device consists of 4 Tandem Roll-on pulleys and 2 Tandem Rib-Top belts. Pulleys are mounted between each set of dual wheels and coupled together with V-belts to transmit power from the live to the dead axle.

The new drive may be adapted



GATES TANDEMATIC V-BELT DRIVE uses split pulley, making it easier to install belt in groove. This method of transmitting power to tandem axles is being used for on-the-highway and off-the-highway equipment.

to freightline transportation fleets of trucks and highway tractor-trailer combinations. Drives will operate many thousands of miles without adjustment, it is claimed. By using 1 or 2 in. of take-up on the axle, maximum service life can be obtained from the belt drive, it is reported.

International Harvester's Select-O-Matic Transmission, introduced about a year ago, is a basic torque converter having a hydraulically operated, single-plate clutch which is combined with a 5-speed synchromesh transmission.

This unit features semi-automatic operation (rather than fully automatic). The torque converter is constantly in operation and serves to reduce shock in the power train. The hydraulic clutch is actuated by finger-tip control at the top of the gearshift lever, eliminating the use of the clutch pedal. Transmission shifting is manual.

Among the arguments favoring this design are (1) the driver has complete control of the vehicle at all times; (2) he may select the gear ratio desired for any traffic or road condition.

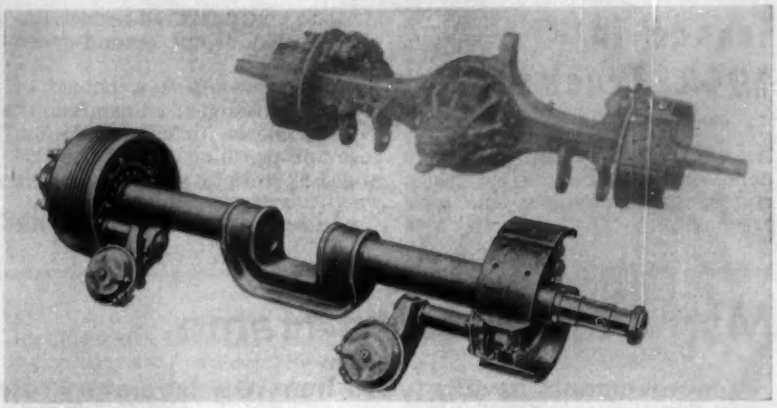
To permit optimum road performance, Reo for 1958 offers a wide range of power and gearing combinations. Transmission and axle ratios have been carefully selected to provide such performance.

Studebaker is offering automatic transmissions for trucks in the 1-ton classification. The non-slip Twin-Traction safety differential is also available. Two-speed rear axles with electric shift are available.

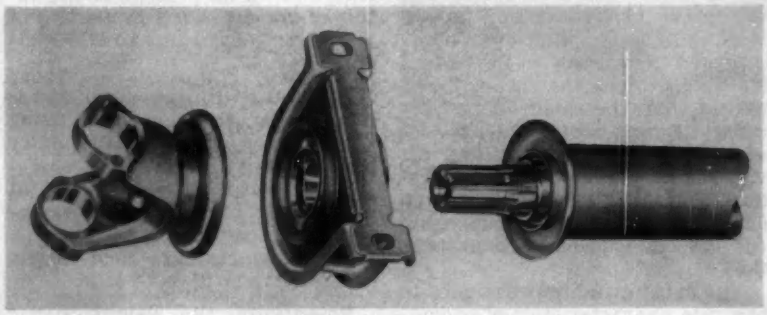
Outstanding features of Rockwell-Standard's new Timken-Detroit TK-500 lightweight trailer axle include alloy-steel, pierced spindles, 1-piece brake spider and flange, lightweight steel hub and drum assemblies. Other weight-saving items include fabricated-steel brake shoes, fiberglass dust shields, and lightweight nylon bushings and supports. Weight saving per axle is reported to be 140 lb.

For 1958, Timken-Detroit is also offering a light-weight tandem that is said to be 200–700 lb lighter than earlier tandem axles having the same capacity.

Timken-Detroit's planetary axles for 1958 trucks range from 20,000 to 75,000 lb. Featured in recent designs are a floating ring gear, centrifugally mounted ring gear hub, and forged bronze planet pinion pins.



TIMKEN DROP-CENTER AXLE can be used with standard single rear axle on either truck or tractor.



SPICER CENTER-BEARING MOUNTINGS are reported to reduce propeller shaft vibration up to 80%.

An unusual axle recently introduced by Timken-Detroit is a drop-center design. This may be used as a standard rear axle on a truck or tractor to produce a light-weight, tandem-axle assembly. The center of the axle is dropped to permit a longer propeller shaft with less line drive angularity.

To meet the growing needs of modern super highways, Timken-Detroit's Wide Range 2-speed double-reduction axles are available. Simplicity of design, optimum ground clearance, and new hypoid gears are featured in the new designs.

New Spicer center-bearing mountings for propeller shafts are reported to reduce vibration up to 80%. The new mounting employs a combination of ball bearing and low-frequency rubber. The center-bearing mounting is available for original equipment as an integral part of the Spicer propeller shaft assembly.

In combination with its two larger gasoline engines, White for 1958 is offering a new 5-speed

Table 1 — Gear Ratios for Fuller R-96 RoadRanger

Gear	Ratios	% Step	
10th	1.0		
		27	
9th	1.27		High
		29	
8th	1.64		Range
		28	
7th	2.10		
		30	
6th	2.73		
Range shift		30	
5th	3.54		
		27	
4th	4.48		Low
		29	
3rd	5.80		Range
		28	
2nd	7.43		
		30	
1st	9.65		

Trends in 1958 Truck Design

...continued

transmission. The new units have helical gears in the four top speeds (instead of three top speeds, used previously). The change was made to give improved service life by adoption of the second-speed helical gear.

White now offers a choice of four RoadRanger transmissions. These choices include aluminum case and bell housings on the R96 and R63 series, making possible weight savings up to 154 lb.

A new Spicer dual-wheel axle was introduced by Willys early in 1958. This is part of the company's program of increasing the gvw rating of its line of vehicles. A substantial gain in payload has been made possible by this new axle.

Four-wheel drive is now controlled with a single transfer case lever.

Many Chassis and Frame . . .

. . . improvements have resulted from new laboratory research techniques, which yield much valuable engineering information. Trend is toward more rigidity, less weight.

Extensive use of stress coats and strain gages is being made for testing in the laboratory and on the proving ground. The data being collected is resulting in newer and stronger designs that are actually lighter than the earlier designs.

Two recent developments deserve special consideration: air suspension (developed and introduced by GMC Truck and Coach Division) and rubber suspension (developed by Hendrickson Mfg. Co.)

The substantial improvement in the ride characteristics of a commercial vehicle through the application of air suspension is the result of the following properties of air springs, according to GMC engineers:

1. Friction in the suspension is eliminated, thereby minimizing transmission of high-frequency disturbances to the vehicle.
2. Air suspension operates at much lower frequencies than conventional suspensions.
3. Frequencies are held nearly constant, regardless of load.

Potentially, the weight saving possibilities of air suspension are very attractive. For example, using light metals wherever possible, it has been shown that in a heavy-duty highway tractor using air suspension (1) tare weight could be reduced nearly 2000 lb, (2) fifth-wheel height could be lowered 5 in. (3) the greatly improved ride would be easier on both the driver and cargo.

At present, two different systems of air suspension are available to truck users.

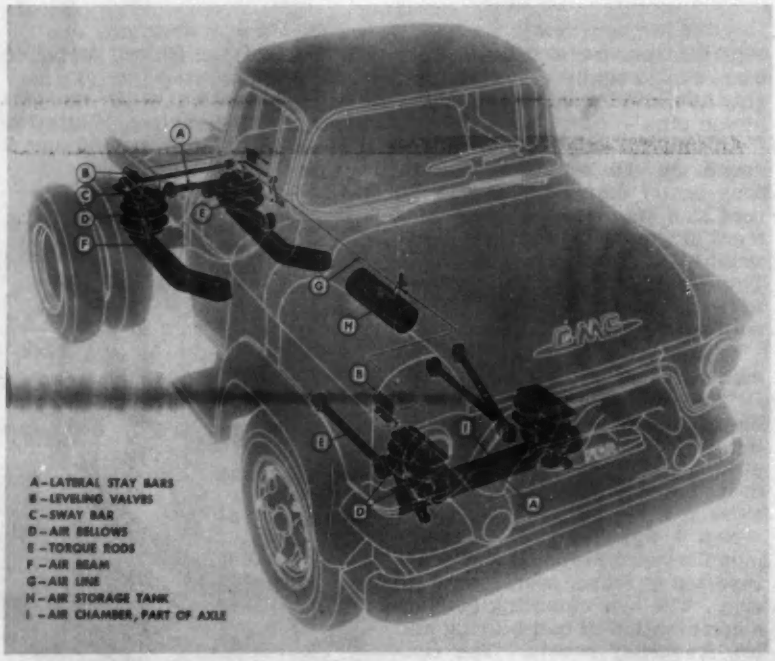
A very recent development in tandem axles is the Hendrickson AR series tandem-axle units, which provide an all-rubber-bushed tandem air spring suspension. The principle of load cushioning, weight distribution, and torque absorption is the same on this air unit as on the Hendrickson RS rubber load cushion and the Hendrickson RT steel spring units.

Air springs are mounted on aluminum spring saddles, which also serve as air reservoirs.

Advantages claimed for the new Hendrickson suspension may be summarized as follows:

1. Constant frame height and axle articulation, regardless of load.
2. Starting and braking torque is absorbed through vertical drive pins.
3. Loss of air does not affect articulation of axles.
4. The need for lubrication and sway bars is eliminated.
5. Spring rate is balanced to load requirements.
6. Significant weight reduction is possible.
7. Permits use of an air spring

Continued on page 102


A – LATERAL STAY BARS
B – LEVELING VALVES
C – SWAY BAR
D – AIR BELLOWS
E – TORQUE RODS
F – AIR BEAM
G – AIR LINE
H – AIR STORAGE TANK
I – AIR CHAMBER, PART OF AXLE

AIR-SUSPENSION SYSTEM used on GMC trucks. Air from compressor is metered into bellows by leveling valves.

Cooling Systems . . .

. . . have better radiator cores and increased frontal areas. Another approach to the cooling problem is the use of twin fans and improved aeration.

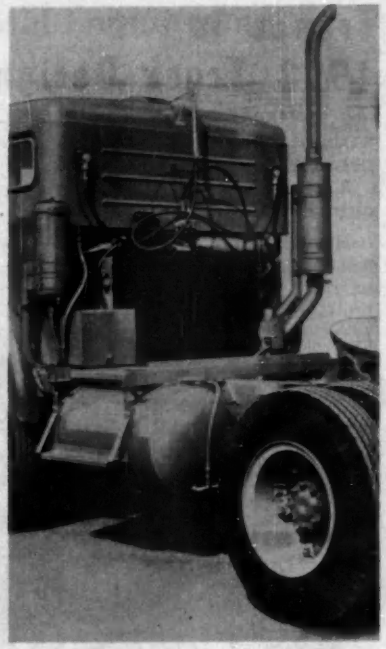
GMC Truck and Coach Division is providing more efficient cooling through the use of cellular and tube-and-center types of radiator core construction.

Models 100 through 250 have a cellular-type core construction with top mounted filler neck and 7-psi pressure cap.

Models 350-8 and 370-8 have as standard a 2.62-in. tube-and-center type radiator with a frontal area of 582 sp in. This is an increase of 11% over 1957 models.

The Kenworth radiator mounting has been redesigned to provide better support. The grille is built in sections. Top and bottom tanks are heavy, cast aluminum; side members are heat-treated aluminum-alloy extrusions. The fabricated shell is completely new and is now fabricated in sections, two side members and the top; any one is replaceable as a unit. The radiator shutter is also made of aluminum. The top radiator tank is replaceable without removal of the radiator.

The new White COE model 3400TD has its radiator mounted in back of the cab. Two fans are used for improved air circulation. There is a single radiator, having two cores. Air is distributed over an area of 1000 sq in. Approximately 250 sq in. of radiator area has been added.



RADIATOR for White 3400TD tractor is mounted at back of cab. It is cooled by 2 blower fans, pulley-driven from an external horizontal shaft.

Tractor-Trailer Combinations . . .

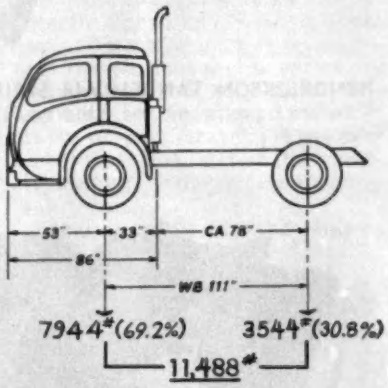
. . . follow legal restrictions and economic factors. The trend toward Forward Control and Cab-Over-Engine models is well advanced.

Overall-length restrictions imposed by many states place a real premium on every inch of length that can be saved in a tractor-trailer combination. Inches taken out of the tractor mean more payload and, therefore, greater earning power for the truck.

Up to the present time three new truck designs have been offered (exclusive of the so-called dromedary) for improving legal load-carrying ability. The advantages and limitations of each basic design are listed in Table 2.

Recent changes in basic truck design permit, for example, 82.6 in. bumper-to-back-of-cab length. This makes it possible to haul a 35-ft trailer within a 45-ft overall limit. Obviously, space is saved both at loading docks and in city streets — at the same time truck earnings are increased because of greater payload.

Due to recent design changes, some truck producers, can now locate the fifth wheel up to 8 in. forward of the axle for standard width, square nose trailers, and up to 19 in. forward of the axle for round nose trailers.



WHITE'S 3400TD will accommodate 40-ft trailers within 50-ft overall length, even with sleeper cab. Units with other values for CA and WB than those shown are supplied.

Table 2 — Advantages and Limitations of Various Truck Designs

	Conventional	LCF	Tilt	48 In.
Accessibility of engine	Good	Fair	Excellent	Fair
Easy entrance and exit for driver	Good	Fair	Excellent	Fair
Short overall length	Fair	Good	Good	Excellent

Trends in 1958 Truck Design

. . .continued

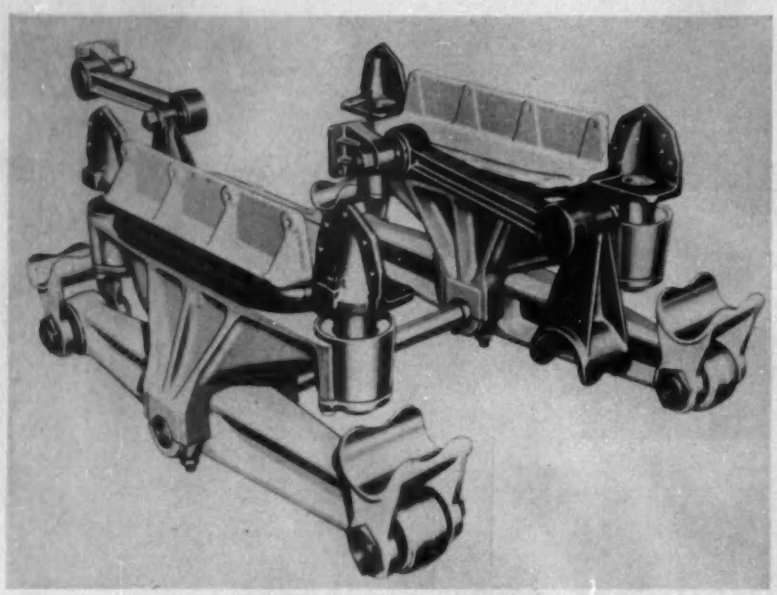
without changing a proved suspension design.

8. No shock absorbers are required.

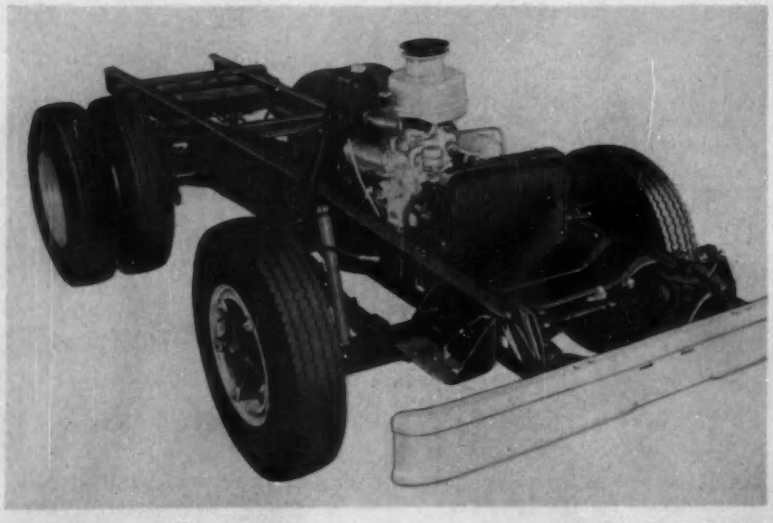
Rubber beam end bushings permit maximum flexibility and absorb oscillating movements. Beam center bushings eliminate the need for lubrication.

A cross tube, connecting the two equalizing beams, assures proper alignment and avoids articulation twist load transfer into the frame.

The new Hendrickson design is said to reduce the effect of bumps and road irregularities on chassis frame movements by 50% while, at the same time, distributing the load equally between the axles.



HENDRICKSON TANDEM AIR SPRING SUSPENSION is all-rubber bushed. Constant frame height and axle articulation can be maintained with this unit.



FORD C-900 has deep channel frame rails to give extra strength and provide resistance to twist and weave.

In its 40, 50, and 60 series, Chevrolet frame side rails have been reformed from the front axle forward.

Chevrolet sedan delivery models have a completely new frame. There is a 30% increase in torsional rigidity over the previous design. The new frame can be used with air suspension and features all-welded box-girder side rails.

The 1958 Chevrolet series 30 forward control and Step-Van models have a new shallow drop-section, I-beam front axle.

An excellent example of efforts being made to provide maximum strength and rigidity — while holding weight to a minimum — is the Diamond T Model 923 frame for 1958. Frame side rails are made of heat-treated alloy steel. The two shortest wheelbase tractor models have tapered channel rails. Straight trucks and longer wheelbases have full depth side rails. Section modulus (two rails) is 23.78. Five or more cross-members are used, depending on the wheelbase.

New for 1958 is a 14,000-lb Dodge front-axle package offered for T900 models as special equipment. Included is a heavy-duty power steering gear, channel-type frame reinforcements at the front, and high capacity 6500-lb front springs. The package is designed particularly for heavy-duty use, including transit cement mixers and high-capacity dump trucks.

Double-wrapped front spring eyes are now featured on all medium- and high-tonnage models. Several 1958 Dodges have increased road clearance.

A progressive-type rear spring has been designed for the Dodge 100 Series. Springs are designed so they stiffen automatically as the load increases. Front springs have a lower deflection rate than the preceding models.

For its new Ranchero models, Ford is using a 4-way ball joint suspension. This is similar to the design used in passenger cars. Rear springs are variable rate.

In its 1958 extra-heavy-duty lines, Ford is using double-channel frame side rails. The new chassis members are engineered to provide extra strength and to resist twist and weave. Side rails have full channel reinforcement from front to rear springs.

GMC has made a number of

chassis and suspension changes in its 1958 models. A heavier, stronger front frame cross-member is used on all GMC models 100 through 370. This change eliminates the need for stabilizer bars.

Six-wheel models have heat-treated frame rails optional.

All conventional and COE models 550 and up have a rear alligator-type cross-member of reduced height. There is a weight saving here of approximately 18 lb without sacrificing strength.

In its dromedary trucks, Kenworth uses air bags over each set of axles. These fill with air as the load increases, maintaining constant frame height.

Kenworth has recently introduced a new drop-frame design in all of its conventional models. The new design shortens and lightens the chassis, permitting greater payload and loading space. Particularly where an aluminum frame is used, weight saving is substantial.

The new drop front end has a variable-section rail. The variable-section drop front achieves considerable weight saving, and mounting of the front bumper has been simplified.

Standard springs are 4 in. wide and 48 in. long. The top or tension side of spring leaves is shot-peened.

Through the use of tubular cross-members, White engineers have added appreciably to the torsional rigidity of its truck frames. On 4400 TD models, Cr-Mo heat-treated steel single channel frames are specified, with four different frames being available. The tubular members are extended to give additional support to fuel tank, transmission, and cab for varying loads and applications. Long wheel bases are also available up to 236 in. on tandem tractors for West Coast usage.

The Hendrickson suspension system is also available on White trucks.

In redesigning its forward control commercial vehicles, Willys Motors (and others) has made an abrupt change in weight distribution. In the case of the Willys FC Jeep, weight distribution ratio has been changed from 30% on the front wheels and 70% on the rear wheels to 50–50 distribution under load.

The new line of Willys FC vehicles has wider and longer springs. Spring leaves are also wider.

Styling and Sheet-Metal Engineering . . .

. . . trend toward Forward Control trucks has been stimulated by both economic conditions and legal considerations. Functional styling is the keyword for 1958.

Shorter, lower, and wider is the trend in modern commercial truck cab styling.

The universal desire — and the economic necessity — to carry more payload while keeping within overall length legal limits are undoubtedly the strongest factors at work in determining today's truck designs.

Engineers agree that when legislative and economic factors are blended with modern styling — to give the truck producer a competitive advantage — the blueprint of a modern truck has been largely determined.

Take an example: in some units 30 in. or more has been taken off overall length by recent styling changes that are dictated, for the most part, by legislation.

In several instances, height has been reduced 3½ in. or more — without loss of headroom. Some of the newer cabs are 3½ in. wider than the models they are replacing.

These are the broad, basic styling trends. Just as significant changes are taking place inside the cabs.

Driver comfort is finally getting the attention it deserves. Drivers' seats are bigger — and much more comfortable. Seat coverings are carefully selected for wear resistance and ability to stay clean. Most trucks nowadays have adjustable seats. There is a strong trend toward cleaner, functional design. Cabs are better ventilated, too,

Trim and interior appointments in many trucks for both business and family use compare favorably with passenger cars. Interior trim on practically all truck cabs is more attractive.

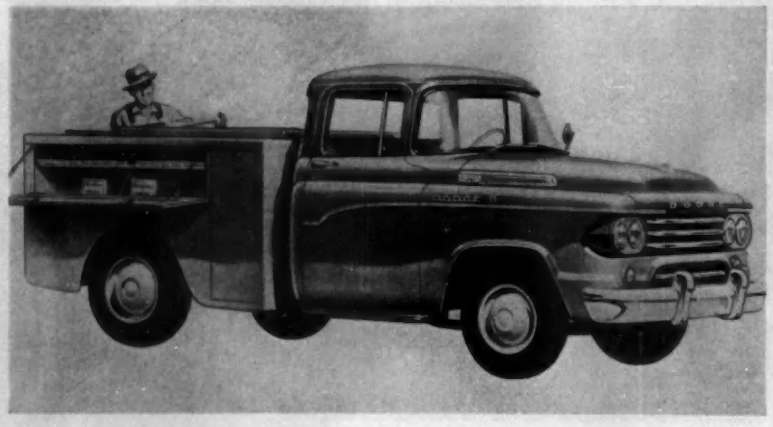
Much attention has been given to making instruments more readily visible.

New Chevrolet hood hinges reduce hood lifting effort. The heavier spring is anchored to the fender skirt rather than the hinge assembly.

Dual 5¾-in. headlamps are standard equipment on all except forward control and Step-Van Chevrolet models.

A scissors-type geometry of the seat suspension receives its support from two heavy rubber members in Chevrolet's new optional seat. Objective here is to maintain the cushion and backrest, as well as the driver, suspended midway between the upper and lower limits of seat travel. The new seat suspension system has self-lubricating bearings, eliminating maintenance.

Rigid, deeply contoured fenders



STORAGE BINS on each side for tools and supplies are featured on this Dodge truck designed for many home service industries.

Trends in 1958 Truck Design

. . .continued

are strengthened by heavily ribbed skirts. The entire unit is strengthened by upper and lower tie bars and diagonal bracing.

Windshield glass area of Chevrolet's sedan delivery models has been enlarged 4.4%. Its 1958 sedan delivery truck has been redesigned so that the rear door becomes a portion of the roof area when closed. Swinging out of the way, the new door gives a bigger opening height and width.

Front end rigidity of grilles has been increased by using a 1-piece grille filler panel to replace a multiple-piece unit.

Typical of other design changes in the 1958 GMC trucks are these features of new optional package-delivery body: safety glass all around, inside lock on side doors, outside locking handles on the curb side and rear doors, and body undercoating. Each of these items is specified on GMC utility bodies. Bumper-to-back-of-cab dimension of GMC D860 is 90 in.

Typical of the 1958 standard cabs is the Dodge, which features safety door latches, driver-adjustable hand brake lever, completely adjustable seat, and single-speed electric wipers, key locks for both doors, right arm rest, and sun visor. Dodge new custom cabs include such extras as wrap-around rear window, foam rubber seat cushions, variable-speed electric wipers, left arm rest, sun visor, acoustical headlining, and glove box door lock. All Dodge cabs include deep-center steering wheel, hooded instruments, quick wind window regulators.

Dodge has new, full-width alli gator-type hoods which open upright to 90 deg Hood side vents reduce engine compartment temperatures. New hinges permit 15% wider openings in cab doors.

Formerly under the floor, the battery is now placed under the hood.

Advantages of COE are well exemplified by the six tilt cabs rerently introduced by Ford to replace earlier cab forward models.

The new design permits a reduction in bumper-to-back-of-cab length to 80.03 in. from 111.1 in. in the conventional truck. More weight on the front axle adds 800 to 1100 lb of payload.

The shortened length also makes it possible to pull a 35-ft trailer and stay within 45-ft overall length limits.

At the same time, forward visibility of Ford's new tilt cab is 1656 sq in., a big gain over the previous model.

Some of Ford's new cabs have 59.5 in. of shoulder room. Other items include wide-opening doors and easy-to-read instrument panels.

For deluxe treatment, Ford's new Ranchero has power seats, power windows, power brakes, power steering, automatic transmission — and air conditioning.

Diamond T's full vision type cabs on Models 922 and 923 have heavy gage, double-wall steel construction. The center post has been eliminated and heat absorbing and glare-resisting one-piece glass is used. The Tilt-cab of the 921C and 923C is largely of aluminum, with fiber-glass plastic roof.

In some of the new Kenworth trucks the dimension from the centerline of the front axle to the back of the cab has been reduced from 91 in. to 86⅜ in. More weight has been imposed on the front axle and there is improved forward visibility.

Fender radii have been increased to accommodate larger diameter tires. The crown has also been widened.

Studebaker's pickup bodies for 1958 have all-steel, double-wall construction. The company is also using a reinforced fiber-glass grille. Pickup bodies are 2-toned as well as the cabs.

PASSENGER-CAR STYLING, performance, and ease of handling combined with load-carrying capacity are characteristics of Ford Ranchero.

FIBER-GLASS GRILLE on Studebaker Transtar half-ton truck permits increased air intake for improved engine cooling.

Two-Stroke Engine

. . . makes great strides. Designing for chain-saw application leads to weight and cost reduction. Powering of target aircraft hints at widening use.

Based on paper by

W. B. Burkett
McCulloch Motors Corp.

(Presented at SAE Salt Lake City Group and SAE Northwest and Spokane Intermountain Sections)

DESIGN developments in chain saws have led to improvements in casting materials, bearings, cylinder design, and carburetion at McCulloch Motors.

Excessive weight, the bane of early chain saws, has been largely overcome by the use of magnesium die castings. Magnesium has been substituted for aluminum, using the same die and without change in the casting design. One model engine uses 16 magnesium die castings, six aluminum, and four zinc castings. Aluminum must still be used where high fatigue and high temperature strength properties are essential such as for cylinders, cylinder heads, pistons, and certain highly stressed structural parts.

Today, we are using 1,250,000 lb of AZ91B magnesium alloy annually. From this two million parts are cast varying in size from a fraction-of-an-ounce knob to a 36-oz crankcase.

Connecting Rod Failure Licked

One of the most common causes of failure in earlier saws arose from the connecting rod being forced against the crank cheek. Various solutions were tried and when success was attained cost reduction accompanied superior performance. The piston pin was press-fitted into the rod and the piston pin needle bearing assemblies were mounted in the piston bosses. A close tolerance was also held between the sides of the bosses and the upper end of the rod. This combination of the straddle-mounted close-fitting bearings and the fit of the upper end of the rod between the piston pin bosses gave the connecting rod a stable mounting and prevented sideways movement of the lower end and the consequent rubbing against the crank pin cheek (Fig. 1). It provided the necessary overspeed performance as well as a sufficient performance margin to permit elimination of expensive cages. Without cages there could be more needles as bearing elements and therefore more load-carrying capacity. This reduction in load-per-rolling element improved the crankpin surface fatigue.

Power Development

The crankcase scavenged version of the 2-stroke engine is used for chain saws because it has the minimum number of working parts, consequently is lightest in weight. The two common types of cylinder scavenging are (1) cross scavenging, in which the incoming charge admitted by the transfer ports is directed into the upper part of the cylinder by a

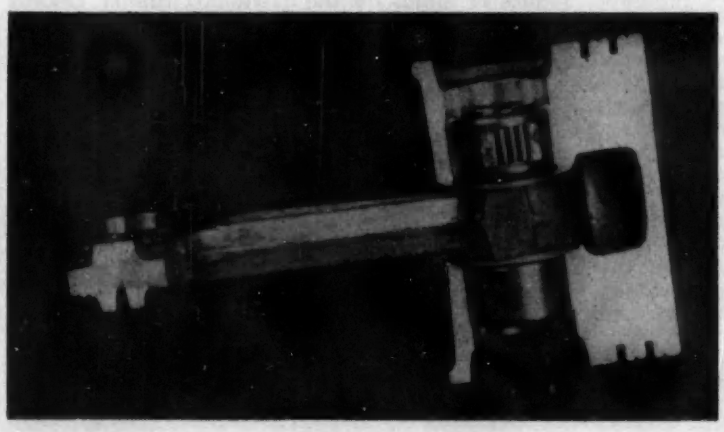


Fig. 1 — Piston pin of McCulloch engine is press fitted into connecting rod. Piston pin needle bearing assemblies are mounted in piston bosses.

deflector on the piston dome and (2) loop scavenging in which the incoming charge is admitted through diametrically opposite transfer ports.

In the loop-scavenging type, used by McCulloch, the charge is directed to the upper cylinder by the angularity of the ports and by the two columns of air impinging on each other. This system is more difficult to develop, but it offers less dynamic restriction to airflow at high speeds and makes possible using a light-weight, flat-top piston presenting the minimum area to hot gases.

With the gaining of an increase in specific output, it has been necessary to solve the problems of cooling the cylinder piston and spark plug which arose with each power increase.

Carburetor For All-Position Operation

The diaphragm-type carburetor employed in chain saws differs from other types in two respects:

1. A nonvented diaphragm chamber is used in place of the conventional vented float bowl system.

2. Provision must be made to close off the high-speed or main jet when the idle system is in operation. This stops leakage which would upset the performance at idle when the saw is run in an inverted position.

The Tillotson carburetor used in the latest saws employs a spring-loaded diaphragm system which maintains the chamber pressure just below that of the atmosphere. Thus, the main jet at idle operation is prevented from leaking by the capillary or surface film seal of the liquid in the main jet line.

To Order Paper No. S62 . . .
. . . on which this article is based, turn to page 5.

Transmission-Differential Combine Is a Way to Lower Cars

Based on paper by

Philip O. Johnson

Fisher Body Division, GMC

A DIFFERENTIAL fixed with respect to the body affords one possible solution to lower cars within the near future. Were this line of design attack pursued, combining the transmission and the differential would be indicated as a means of developing a suitable rear-suspension and rear-axle arrangement.

Such a "transaxle" would eliminate the transmission hump in the front floor — which must be accomplished if we are to build truly low cars. Essential to further lowness, in fact, is reduction in height — or elimination of — the driveshaft tunnel. . . . And, since elimination probably involves rear-engined or front-drive designs, possible-in-the-near-future approaches must look for some way to reduce the height of the driveshaft and/or the space which must be provided for the jounce clearance.

A driveshaft that is stationary with respect to the rear seat eliminates the tunnel jounce clearance but conventional universal joints connected to a vertically moving rear axle are impractical. The angles are too severe and the space too limited. Also the jounce and rebound requirements of the rear wheels are already at or near minimum values. Yet, a practical, economical solution to this problem is required for very-low-profile cars.

The combination of the transmission and differential is one approach which comes within this "practical-now" framework.

If the transmission were placed in the rear, it would almost certainly have to be fully automatic or semi-automatic. Straight manual control would be difficult to achieve satisfactorily.

Very small gains toward further lowness seem feasible through modification of other elements of front-engined, rear-drive cars. Only a small gain could be hoped, for example, through reduction of ground clearance. Little additional lowness could be attained by making thinner the cushion depth over the driveshaft. . . . or by reducing the distance from the normal deflected contour of the cushion to the roof.

Assuming that some successful way is found to reduce or eliminate the driveshaft tunnel, chassis frames might be redesigned to help toward even lower body profiles and even more interior body roominess. The center section of the X-frame, for example, could be extended — or the rail-frame squared off.

In any case, the height of the driveshaft tunnel, not the type of chassis frame, is currently the limiting factor to low cars. Various approaches to getting more lowness can be taken with either an integral or a separate chassis frame. This becomes apparent when we realize that, in present cars, no structural members are placed directly under the centerline of the rear seat.

To Order Paper No. S93 . . .
. . . on which this article is based, turn to page 5.

COOPERATIVE ENGINEERING PROGRAM

Correction Factors Sought For Diesel Engine Test Code

Based on paper by

A. K. Blackwood,
International Harvester Co. and

M. A. Elliott,
Institute of Gas Technology

REVISION of the current SAE Diesel Engine Test Code has revealed the need for correction factors that better match actual engine performance. Also unearthed was the need for a new set of base-line atmospheric conditions.

Although standard atmospheric conditions have been tentatively agreed on, as yet no firm conclusions have been reached on correction factors.

The atmospheric conditions decided upon correspond to an altitude of 500 ft (barometric pressure 29.38 in. of Hg), a temperature of 85 F, and a relative humidity of 50%, a standard also adopted by the British.

In seeking correction factors based on the effect of load as well as variations in atmospheric density, the Diesel Engine Test Code Subcommittee feels the factor should be based on a fixed fuel flow rather than a fixed fuel-air ratio.

Several methods for making such corrections have been tried. One, which appeared to give promise of leading to a general correction factor for all engines, was studied intensively. It was based on a relationship between per cent of maximum indicated horsepower and per cent of maximum fuel/air ratio.

Fig. 1 shows the average relationship for various engines and indicates a significant deviation from the average in individual engines.

Analysis of data on several engines showed that an average curve could not be used to give an accurate correction factor for all engines. In view of this and the fact that complex calculations and correction procedures are required, the subcommittee abandoned the method.

Another approach to correcting power output for variations in atmospheric conditions assumes that engines will operate at the same fuel/air ratio under standard conditions as under test conditions. This type of correction factor is generally applied to carbureted engines. When applied to diesel engines, a tacit assumption is made that the smoke density will be the same at the standard condition as it is at the test condition. However, under fixed throttle test conditions, the fuel/air ratio does not remain constant, as would be indicated by the constant fuel/air ratio type of correction factor.

Fig. 2 shows the consequence of maintaining a constant fuel/air ratio in correcting for power output. The T to S_1 relationship shows a significantly different result as compared

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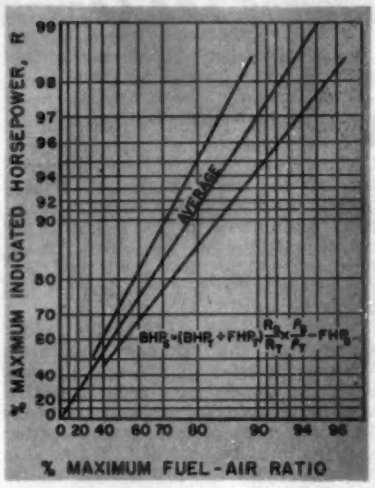

FIGURE 1 — Performance of individual engines indicates a large deviation from the average when maximum indicated hp is related to maximum fuel-air ratio. Because of complex correction, method was abandon.

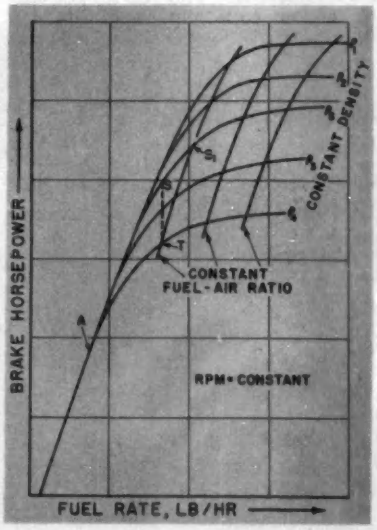

FIGURE 2 — The consequence of maintaining a constant fuel/air ratio in correcting for power output is shown. The T to S_1 relationship reflects a significantly different result as compared with the constant fuel consumption method.

DIESEL Engine Test Code Subcommittee efforts to revise the current SAE test code are based on an industry need for a more accurate standard laboratory procedure for measuring the power output of diesel engines. When completed, the new test procedure will be applicable to 2-stroke and 4-stroke cycle engines, whether naturally aspirated, mechanically supercharged, or turbocharged.

In brief, it will prescribe instrumentation for performing the tests and methods of calculation including corrections for variations in atmospheric conditions. Instructions for preparing curve sheets and recording test data will also be supplied.

The code is not meant to establish horsepower ratings, smoke ratings, or derate engines for altitude. Nor is it a detailed laboratory manual.

Missile Director Holaday Praises SAE Committees

William M. Holaday

WILLIAM M. HOLADAY, director of the Guided Missile Program for the Defense Department and current member of the SAE Technical Board, praised the work of the Society's technical committees at the recent Aeronautic Meeting in New York. In a luncheon talk, Mr. Holaday linked SAE committee work and missilery in the following way:

"Thus far we have made great strides in our missile programs. Weapon systems which are a great deterrent to war have been placed in the hands of our military services. But we must progress, and better systems must be provided. To do this we must move forward quickly in the areas of basic research, advanced engineering, and quality control. Weapon systems must also be simplified.

"Over the years, this Society has played an important part in all these areas — particularly so with respect to standardization. This has led not only to reduced costs and complexity, but to improved reliability of our weapons.

"Equipment of the types carried in guided missiles has never before been subjected to such terrific environmental conditions. The shock of launching, accelerations, vibrations, and heat are an order of magnitude more stringent than any previously encountered. And yet, reliability must be extremely high. This has led to manufacturing, assembly, and testing techniques which might almost be looked upon as a new engineering field; and never before has quality control assumed such importance. In short, reliability is the key to successful missilery, and without it we have nothing.

"For these reasons I am particularly pleased to see the Society broaden its scope of activity to include missile engineering. Here the technical meetings and committee work may have even more significance than in the aeronautical and automotive fields. Your work has always been good, and I wish you ever increasing success in the future."

Correction Factors—Continued

with the constant fuel consumption method.

The constant fuel/air correction requires the following correction:

$$bhp_s = (bhp_t + fhp_t)\frac{d_s}{d_t} - fhp_t$$

where:

s = standard
t = test
d = density
fhp = friction horsepower

Assumptions made in deriving this relationship are:

(1) At constant fuel/air ratio, indicated horsepower is proportional to ambient air density.

(2) Friction horsepower is constant at test and standard conditions.

(3) Volumetric efficiency is constant at test and standard conditions.

This relationship has been found to apply to each of the engines tested. By a somewhat complex graphic procedure, it is possible to develop the constant-fuel-rate type of correction factor from data obtained by making corrections at constant fuel/air ratio. However, this method has not been applied extensively, and only one engine manufacturer has reported on its use.

At present, it is not possible to establish a correction factor for diesel engines that will apply to *all* engines under *all* operating conditions. However, the subcommittee maintains the importance of developing a correction factor which may be used in day-to-day and comparative tests.

To Order Paper No. 64B . . . on which this article is based, see p. 5.

New SAE Test Controls Quality of Brake Linings

A UNIFORM method of checking the quality of production brake linings has been approved by the Technical Board as a new SAE recommended practice. It is the first quick-check method of its kind to be developed for industry use.

Gives Accurate Check

In addition to being quick and simple, the test enables a user to make an accurate and economical quality check during a production run.

Test procedure requirements are based on the original test data which qualify a lining material for a given application. Wear and friction characteristics are the two properties tested.

The new report was developed by the Brake Linings Subcommittee of the Brake Committee and is scheduled to appear in the 1958–1959 Handbook.

Carbon Steel H Bands Explored by New Group

FEASIBILITY of hardenability bands for carbon steels is being explored by a new Iron and Steel Technical Committee task group. If developed, the specifications will parallel the alloy steel hardenability bands which first appeared in the Handbook ten years ago.

Since the control of carbon steel hardenability is essentially determined by only two elements, carbon and manganese, task group members expect their work to be more difficult than what was required to develop the alloy steel H bands.

A comparison will be made of calculated hardenability based on the chemistry of selected carbon steels *and* actual hardenability, according to Chairman G. K. Manning, Battelle Memorial Institute. Data on a small number of grades currently in use will be gathered from a large number of heats from different mills.

Initial Project

As an initial project, members selected SAE 1041 and SAE 1045 as the first steels for study. Calculated and actual hardenability information on alloy steel SAE 1340 will be used for comparison with the data developed on SAE 1041 and SAE 1045.

Also under consideration is the feasibility of determining hardness of carbon steels for 50% martensite and plotting the Jominy distance to this Rockwell. The method might eliminate a calculation variable resulting from the fact that a variation in carbon content will vary the location of the Rockwell hardnesses on the Jominy scale.

Trowbridge Leads U. S. Team at ISO Meet Abroad

ADOPTION of a complete unified screw thread system was proposed by SAE's R. P. Trowbridge who led a 9-man U. S. delegation at the International Standards Organization meeting held last month in Harrogate, England. Based on a made-to-the-inch thread system, the proposal has already been accepted by the American-British-Canadian Conference.

The U. S. group also participated in ISO and ABC discussions on screw thread gaging, gaging tolerances, and designations.

In addition to Mr. Trowbridge who is director of the Engineering Standards Section at General Motors, the following served as U. S. delegates: R. B. Velfort, Robert Byrnes, I. H. Fullmer, W. H. Gourlie, E. J. Heldmann, G. H. Stimson, W. G. Waltermire, and Frank Philippbar.

Seat Belt Loop Load Increased by 1000 Lb

AN INCREASE from 3000 to 4000 lb in the minimum loop load requirement specified in the SAE recommended practice on Motor Vehicle Seat Belt Assemblies has been approved by the Technical Board. The rated minimum tensile strength of the webbing has also been raised from 2250 to 3000 lb.

This is the third revision of the recommended practice since it was originally approved in 1955. To identify it as such and to facilitate references to it on labels, it has been designated SBA4.

The revised report will appear in the 1958–1959 Handbook.

Revised Turn Signal Spec Requires Visual Tell Tale

VISUAL turn signal tell-tales are now required to show that a system is turned on *and* functioning normally, according to the recently revised SAE Standard on Turn Signals. The visual signal may be supplemented with an audible one. Before, either visual or audible signals were acceptable.

Other changes in SAE lighting reports which have been approved by the Technical Board for inclusion in the 1958–1959 SAE Handbook are:

- Modification in the laboratory photometry distances for tail, stop, turn signal, and back-up lamps.
- A new tabulation of 12-volt lamp bulbs and sealed units for heavy-duty commercial vehicles.
- Changes in the sealed-beam head lamp drawings.
- Deletion of composite sealed-beam units which are no longer made.

Technishorts . . .

COMPRESSION SPRINGS — A uniform method of establishing tolerances for compression springs used in transmission control bodies, servos, and clutches has been approved by the Technical Board. Developed by the Transmission Committee, it will appear in the 1958–1959 Handbook as a new SAE recommended practice.

TURBOCHARGER CONNECTIONS — A new SAE recommended practice on turbocharger connections has been developed to facilitate standardization of mating engine connections and gaskets. As a result, greater flexibility is possible in engine testing procedures. The report which is scheduled to appear in the 1958–1959 Handbook was developed by the Engine Committee.

MOUNTING FLANGES AND POWER TAKE-OFF SHAFTS FOR SMALL ENGINES — Mounting flanges for 2- and 4-stroke engines with a rating of less than 6 bhp have been linked with appropriate power take-off shafts in a new SAE recommended practice. The report will be included in the 1958–1959 Handbook.

AN AUSTRALIAN TRACTOR TEST CODE was recently found to reference three SAE Standards. Included are oil, belt pulley, and power take-off specs.

Aircraft Engine and Accessory Group Hears SAC Headquarters Personnel

UNDER THE PROTECTIVE WINGS of a B-47 at SAC's Lincoln Air Force Base are members of SAE Joint Aircraft Engine and Accessory Installations Committee. During a 3-day meeting, members toured Lincoln facilities and were told of SAC's mission by SAC Headquarters personnel from Offutt Air Force Base, in Omaha.

First row, left to right: Lt. V. L. Kovacich, Lt. C. K. Roberts, Capt. A. R. Masseimi. Second row: R. M. Seeley, B. R. Teree, R. F. Schwarzwalder, Committee Chairman D. L. Cauble, V. W. Peterson, M. M. Steele. Third row: R. R. Miille, W. R. Kruesi, G. D. McGhee, M. J. Leonard, S. E. Gail, E. G. Emery, Jr., J. R. Toth, K. I. Postel, A. E. Schmidlin, Leonard Wolfson, D. H. Parker, W. H. Hand, R. C. Morlath, Maj. R. N. Leone.

About SAE Members

Raymond

Moody

Green

Davey

Banks

LEONARD RAYMOND, currently an SAE Councilor and chairman of SAE's Publication Committee, has been promoted to chief automotive engineer — research, of Socony-Mobil Oil Co. He will coordinate both long and short range Socony-Mobil automotive engineering research with present and future developments in automotive vehicle and equipment designs. **L. F. MOODY, JR.,** previously senior engineering representative of Socony-Mobil lubricating department replaces Raymond as chief automotive engineer of that department.

ARTHUR W. F. GREEN has retired from General Motors Corp.'s Allison Division as technical assistant to the executive engineer, a position he has held since 1956.

From 1938 to 1945, Green served Pratt & Whitney Aircraft's Missouri operation, and in 1946 joined the Allison Division as chief metallurgist.

Effective July 1, 1958, Green will be living at 7 Maywood Lane, Menlo Park, Calif. His plans for the future include remaining active in the many phases of engineering that have comprised his career.

CLARENCE G. DAVEY retired from General Motors Corp. on June 1 after serving as a key engineering executive with the AC Spark Plug Division for more than 39 years. Since 1947, he has been executive engineer in charge of AC's automotive engineering model shop, test laboratory, production drafting, blueprinting, records, and other administrative services.

Davey, who has earned recognition for his contributions to engineering standards, has for some time been active in the American Standards Association.

From 1946 to 1952, he was national chairman of the tube, pipe, hose and lubrication fittings committee of SAE, and in 1954 was cited by its technical board for his contributions.

AIR COMMODORE FRANCIS R. BANKS, a director of the Bristol Airplane Co., has been named vice chairman of the newly formed company of Bristol-Siddeley Engines, which combines activities of Bristol Aero-Engines and Armsrtong Siddeley Motors, Ltd.

ROBERT W. MIDDLEWOOD has been named director of the newly-formed Georgia Nuclear Laboratories, a branch of the Georgia Division of Lockheed Aircraft Corp. He is succeeded as chief engineer of the Georgia Division by **WILFRID A. PULVER,** who had been assistant chief engineer of the division. Pulver has been with the corporation since 1936.

WALDON R. RHOADS, who has been director, Nuclear Aircraft Laboratory, Georgia Division, is manager of operations for the Nuclear Laboratories staff.

CLINTON E. SARTWELL has been elected vice-president and director of engineering for Oshkosh Motor Truck, Inc. He has been chief engineer for the corporation since 1934.

COLLIS H. HOLLADAY, JR., is now a junior engineer with the Mobil Producing Co., in Billings, Mont. Previously he was an engineer trainee with the General Petroleum Corp. in Los Angeles.

JACK E. MAXCY has become equipment sales manager for Hoover Bros., Inc., in Temple, Tex. Prior to this he was with the Bendix Aviation Corp. in South Bend, Ind., as design engineer.

STEVE E. COLUCCI, formerly a research engineer with the Stratos Division of Fairchild Engine and Airplane Corp., Bay Shore, N. Y., is now a development engineer "A" for Aerojet General Corp. in Sacramento, Calif.

HERBERT M. BEVANS has been appointed executive engineer for chassis, electrical and truck, in the Engineering Division of Chrysler Corp. He had been chief engineer — vehicle testing, since January, 1956.

Succeeding Bevans is **WILLIAM R. RODGER,** who will be in charge of the Engineering Proving Grounds near Chelsea, Mich. Rodger was assistant chief engineer — chassis for the division prior to his new appointment.

PAUL KLOTSCH is now manager of the product development department, engineering research and advanced product study office, Ford Motor Co. He joined the company in 1951, and prior to his new appointment, was manager, mechanical department of the scientific laboratory, engineering staff of Ford.

At Ford Motor Co., **JAMES KNOWLES** is executive assistant to the vice-president — manufacturing. Previously he had been chief engineer, product engineering office, transmission and axle group. He has been with the company since 1945.

BURTON C. ERICKSON has become chief engineer of the product engineering office, Transmission and Chassis Division of Ford. He joined the company in 1945, and in March, 1958, became an executive engineer in the transmission and axle group, which was later reorganized as the Transmission and Chassis Division.

V. J. JANDASEK is executive engineer for advanced transmission and experimental engineering in Ford's Transmission and Chassis Division. He joined the company in 1950 and was assistant transmission engineer and manager of the advanced transmission engineering department at the staff level prior to his new position.

HAL C. GOOCH has become senior lubricants engineer in the newly formed technical service section of the lubricants supply department, Eastern Division, Tidewater Oil Co. Formerly he was technical service supervisor in the marketing department.

In the same section, **EVERETT C. POST,** formerly of technical service, was named lubricants engineer.

Middlewood

Pulver

Rhoads

Sartwell

CAPT. JOHN JAY IDE has been elected vice-president of the Federation Aeronautique Internationale. The FAI — an international grouping of all aero clubs, with headquarters in Paris — was founded in 1905.

Captain Ide will attend its next conference which will be held in Russia (for the first time) in May 1959.

WELLINGTON R. GRAHAM has retired as administrative engineer for Purolator Products, Inc. He joined Purolator in 1925 as a chief draftsman.

Graham is the holder of patents on electric truck direct drive units and has contributed articles to the technical press on both production and design subjects. He has been a member of SAE since 1922.

JOHN A. GILLIES has become director, maintenance and engineering, for Canadian Pacific Airlines, Ltd. He was chief engineer prior to his new position. He succeeds **IAN A. GRAY**, who is now assistant vice-president — operations, for Canadian Pacific.

MICHAEL R. KRAUSE is now manager of engineering for the Dodge Truck Division of Chrysler Corp. Prevously he was assistant chief engineer, truck design, with the Engineering Division of Chrysler.

Krause has been a member of the SAE Truck and Bus Activities Committee for 1957.

BRIG. GEN. HAROLD R. HARRIS, USAF (Ret.), has been elected president of the Wings Club, which serves as a New York center for the members of the aviation industry. He is president of Aviation Financial Services, Inc., and former president and chief executive officer of Northwest Airlines.

Among other officers elected were **JOSEPH S. HARRIS**, manager, aviation department of Shell Oil Co., as vice-president, and **JEROME LEDERER**, managing director of the Flight Safety Foundation, as secretary.

HERBERTH E. HEAD, of Chrysler Corp., is the new president of the American Electroplaters' Society.

WILLIAM B. BERGEN, who has been executive vice-president of the Martin Co., is now a director of the company.

STANLEY C. PACE is now assistant manager of the newly-formed Tapco Group at Thompson Products, Inc., and has been elected a vice-president. For the past three years he has been manager of the Jet Division.

RICHARD F. GOMPERTZ has become manager — rocket engineering, for the General Electric Co. Formerly he was director, Rocket Engine Test Laboratory, Department of the Air Force, Flight Test Center, Edwards, Calif.

GERALD E. JEROME is now product planning analyst for the M-E-L Division of Ford Motor Co. Previously he was in the same position on the central staff of the company.

MYLES ANDERBERG is now tool design engineer for the Boeing Airplane Co. in Seattle, Wash. Previously he was applications engineer for the Hubbs Engine Co. in Boston.

EDWARD F. PERRY, formerly a project design engineer for Canadian Car Co., Ltd. in Quebec, is now a development design engineer for the Northern Machine Works in New Brunswick, Can.

RUDOLPH M. BOGRE is now with the Rocketdyne Division of North American Aviation, Inc., in Canoga Park, Calif., as research engineer, ground support equipment. Previously he was a project engineer, Department of the Army, Ordnance Tank Automotive Command, Detroit Arsenal, Center Line, Mich.

RUSSELL S. ATKINSON has become western regional manager for Aerol Associates, the sales-engineering division of Cleveland Pneumatic Industries, Inc. Prior to his new appointment, he was general sales manager of National Water Lift Co. of Kalamazoo, Mich., another division of the corporation.

NORMAN C. JOHNSON, formerly research engineer, Battelle Memorial Institute, Columbus, Ohio, is now G.S. 7 mechanical engineer in the U. S. Army Corps of Engineers, Walla Walla, Wash.

HOWARD M. GAMMON has become executive assistant for Purolator Products, Inc., in Rahway, N. J. Recently he had been with Westinghouse Electric Corp., and prior to that was chief engineer for the Motor Equipment Division of Thompson Products, Inc.

ROBERT J. CRAVER is now a project engineer with the Champion Spark Plug Co.; formerly he held the same position with the Electric Auto Lite Co.

JAMES F. BUECHE, formerly research engineer with the Ford Motor Co., is now an engineer with the General Electric Co. in Cincinnati.

ROY E. VAN SICKLE is now an engineer — products application, for the Shell Oil Co. Prior to this he was fuels group leader for the Martinez Research Laboratory of the company.

PAUL R. WILEY has become associate engineer in the airplane design group of the McDonnell Aircraft Co. in St. Louis, Mo. Previously he was with the Bendix Products Division of Bendix Aviation Corp.. in South Bend, Ind.

ALEXANDER A. SINCLAIR is now with Sinco Products, Inc., as president and general manager. Prior to this he was associated with the Sinclair Distributing Co.

WILLIAM R. ALEXANDER, director of engineering, The Steel Products Engineering Co., Division Kelsey-Hayes Co., spoke at the Fifth Annual Conference for Engineers and Architects at Ohio State University on May 2nd. The subject of his talk was "Mechanical Design Problems of Components in High-Performance Spacecraft."

BURROWES G. STEVENS, JR., has been made project engineer in the Chevrolet engine design group, General Motors Corp., with responsibility for passenger car engine valve train components. He has been with Chevrolet since 1954, and was a Chevrolet engine development engineer at the General Motors Proving Ground prior to his new appointment.

At the Oil and Gas Power Conference of the American Society of Mechanical Engineers, beginning May 12 in New York, papers were presented by **EARL J. BECK, JR.**, a project engineer

for the U. S. Naval Civil Engineering Research and Evaluation center in California; **PANDELI DURBETAKI**, professor at the University of Rochester, N. Y.; and **AUGUSTE F. MOIROUX**, of La Société, L'Etudes Mécaniques et Energetiques of Paris.

ROBERT C. NORRIE has been appointed general manager of Kenworth Motor Truck Co., division of Pacific Car and Foundry Co. He has been with Kenworth since 1934 and was chief engineer prior to his new appointment.

Norrie is SAE past vice-president representing Truck and Bus Activity for 1955, and past chairman of the Northwest Section of SAE.

WALLACE M. BROWN succeeds Norrie as chief engineer at Kenworth. He has been with the company since 1936; prior to his new position he was chief engineer — trucks, at the Renton plant of Pacific Car and Foundry Co. Brown is vice-president of the Northwest Section of SAE.

Through executive appointments in the Plymouth Division of Chrysler Corp., **JOHN C. GUENTHER** has become executive assistant to the general manager, and **JACK E. CHARIPAR** is chief engineer and director of product.

Guenther joined Chrysler in 1952 and was executive assistant of the product volume planning department prior to his new appointment.

Charipar was supervisor of new product plans in the Export Division before his assignment to Plymouth.

RICHARD J. WILLIAMS has been named executive vice-president of American Metal Products Co.; previously he had been vice-president of research and development for the company.

Succeeding Williams is **FREDERICK C. MATTHAEI, JR.**, who formerly was secretary of the company.

STEPHEN J. TOMPKINS, formerly chief engineer, truck operations, Dodge Division of Chrysler Corp., has been appointed to the newly created position of chief engineer and director of truck product.

In the same division, **GEORGE W. GIBSON, JR.**, has been named chief engineer and director of car product. He had been staff engineer, Automotive Group, with Chrysler.

ZENON C. R. HANSEN, president of the Diamond T Motor Truck Co., a wholly owned subsidiary of the White Motor Co., has been elected a director of the White Company, and executive vice-president and general manager of the Diamond T Division.

At the same time, **WILLIAM F. BURROWS**, general manager of the White Diesel Engine Division, Springfield, Ohio, was appointed vice-president and general manager — Diesel Engine Division.

At Mack Trucks, Inc., **THEODORE J. ZELLER**, vice-president, Forward Planning Department, will assume overall charge of parts supply and service engineering activities.

HARVEY W. BUSH, vice-president — Allentown, Pa., Operations, has been placed in charge of manufacturing operations for the entire company.

DONALD D. ROBERTS, formerly a sales engineer for the Valve Division of Eaton Mfg. Co., has been made sales manager of the division. He has been with the company since 1951.

PETER F. HURST, president of Aeroquip Corp., has been elected to the board of directors of Clark Equipment Co.

LEONARD M. KULZE has become factory manager of the Gibson Division of Associated Spring Corp. He joined the division in 1929, and was chief engineer prior to his new appointment.

RICHARD E. CLAY has been appointed manager, automotive sales, for the Aluminum Division of Olin Mathieson Chemical Corp. He had been assistant manager, automotive sales, prior to his new position.

WILLIAM W. SEATON is now with American Automation Corp. in Ann Arbor, Mich., as assistant to chief engineer and office supervisor. Prior to this he was a project engineer with the Coffing Hoist Division of the Duff-Norton Co., in Danville, Ill.

ARTHUR C. HARTMAN, JR., formerly production manager for The Simplex Equipment Corp. in Bloomfield, N. J., is now production superintendent, Electronic Systems Division of the Dalmo-Victor Co. in Belmont, Calif.

WILLIAM C. HESTER is now assistant publications director with Vickers, Inc., Division of Sperry Rand Corp. Formerly he was with the Continental Aviation and Engineering Corp. as a copywriter.

DOUGLAS ANDREW is now garage superintendent for McCallum Transport in Oakville, Ont., Can. Previously he was field service engineer for La France Fire Engine & Foamite, Ltd., in Toronto.

PHILIP F. PETERSON is now an engineering writer for the AC Spark Plug Division of General Motors Corp. in Milwaukee, Wis. Formerly he was technical publications analyst for the General Electric Co. in Lynn, Mass.

M. J. McCARTY, formerly sales manager for the Active Gear Co. in Chicago, is now with the Water Conditioning Equipment Corp. in Ft. Lauderdale, Fla., as secretary and treasurer.

Norrie

Brown

Guenther

Charipar

Williams

Matthaei

Tompkins

Gibson

T. ROSS WELCH has become general manager of TC Components Division of Brubaker Electronics Co., a subsidiary of Telecomputing Corp. Formerly he was director of research and development for the Electronics Division of Elgin Watch Co.

L. DYKES MEREDITH is now with Dorsey Trailers in Elba, Ala., as administrative assistant to the vice-president in charge of sales. Previously he was treasurer, assistant secretary, and general manager for the Brown-Clark Equipment Co. in Richmond, Va.

LEO KAPLAN, formerly service engineer for the General Electric Co. in Cincinnati, is now field and flight test engineer for the company in Lynn, Mass.

JOHN W. BROOKS has become technical sales representative for the Remington Arms Co. Previously he was research engineer in the research and development department of the company.

CLAYTON N. THOMPSON has retired as Detroit engineering representative for the A. O. Smith Corp. He has been with the corporation since 1935.

Hansen

Burrows

Zeller

Bush

Roberts

Hurst

Kulze

Clay

ROBERT L. COLLINS has become planning and engineering manager for the M-E-L Division of Ford Motor Co. in Metuchen, N. J. He had been manufacturing operations manager of the Edsel Division of Ford in Michigan.

JOSEPH KROLL, formerly assistant resident manager for Kaiser Engineers, Division of Henry J. Kaiser Co., is now owner's representative for Kaiser Center, Inc.

THOMAS S. TAYLOR is now brake research mechanical engineer for the American Brake Shoe Co. at the Research Center in Mahwah, N. J. Prior to this he was Chrysler Research Senior Engineer, Chrysler Engineering, Chrysler Corp.

ROBERT J. ARMSTRONG, formerly propulsion service engineer for Bell Aircraft Corp. in Buffalo, N. Y., has become service engineer for the Transport Division of Boeing Airplane Co. in Renton, Wash.

HENRY H. MICHAELS, JR., is now assistant general manager, Reaction Motors Division, and assistant secretary, Thiokol Chemical Corp. Formerly he was senior vice-president of Reaction Motors, Inc.

Sloan Fellowships for a year of advanced study at Massachusetts Institute of Technology have been awarded to **EUGENE R. KARRER**, section supervisor in body and electrical engineering for Ford Division, Ford Motor Co., and **FRANKLIN WALTER**, assistant chief engineer in the central engineering body development design section of Chrysler Corp.

Reaction Motors, which has become Reaction Motors Division of Thiokol Chemical Corp., has announced new titles for its chief executives.

RAYMOND W. YOUNG, former president of Reaction Motors, is now general manager of the Reaction Motors Division of Thiokol Chemical Corp.

DAVID C. EATON, formerly vice-president of Reaction Motors, is now director of marketing at the Reaction Motors Plant.

NORMAN G. SHIDLE, SAE's manager of publications, has been elected chairman for 1958–1959 of the Alumnae Advisory Center of New York. The Center, sponsored by leading women's colleges, is a vocational and career guidance agency for women college graduates.

GEORGE C. SCOTT has become application engineer for the Industrial Division of Watts Regulator Co. in Lawrence, Mass. Previously he had been with Gulf Oil Corp.

Speakers at the five day meeting of the American Society of Mechanical Engineers, beginning June 15 in New York, included: **NEVIN L. BEAN** of the Ford Motor Co.; **K. T. KELLER**, formerly president and chairman of the board of Chrysler Corp.; and **JAMES C. ZEDER**, vice-president of engineering and special advisor to the president of Chrysler Corp.

At the 62nd annual convention of the American Foundrymen's Society held in Cleveland May 19-23, **RALPH A. CLARK** was awarded the Pangborn Gold Medal. He is manager of foundry services, Electro Metallurgical Co., division of Union Carbide Corp.

FRANKLIN B. ROTE, technical director, Albion Malleable Iron Co., received an Award of Scientific Merit from the society.

THOMAS W. CURRY, director of research, Lynchburg Foundry Co., is a director-elect of the society.

WILLIAM J. FRITTON, marketing vice-president of the U. S. Rubber Reclaiming Co., Inc., has been elected to the board of directors of the company.

JOHN L. HOOVEN is now executive engineer, Thunderbird product engineering, Ford Division, Ford Motor Co. Formerly, he was executive engineer, advanced truck product engineering.

EDWARD J. FORISCH has been made engineering assistant to the president of Aerol Associates, a Division of Cleveland Pneumatic Industries, Inc. For the past 18 years he had been a staff engineer with the Airsupply Division of the Garrett Corp.

WALTER T. CZUBA has joined the staff of the experimentation center operated by Technical Operations, Inc. for the Continental Army Command. Previously he had been associated with the AiResearch Mfg. Co. of Arizona, Division of the Garrett Corp., as design engineer, power turbines.

L. K. COVELLE, JR., has been appointed vice-president and general manager of Willys-Overland Export Corp. Formerly he was assistant to the vice-president and general manager of Willys Motors, Inc.

F. RUSSELL VALPEY has been made president of the Standard Products Co. Formerly he had been senior vice-president of the company.

JAMES S. REID, who had been president of the company, continues as chairman of the board.

RAYMOND F. WINCH, chief of the Fuel Development section, Research and Development, Sun Oil Co., has won a 1958 Sloan Fellowship for a year's executive development training at Massachusetts Institute of Technology.

Obituaries

CLIFFORD DUHME . . . (A '46) . . . head of Avondale Chevrolet Co., truck sales . . . had been with the company since 1928 . . . died March 31 . . . born 1889 . . .

WALTER FERRIS . . . (M '23) . . . vice-president, consulting engineer for The Oilgear Co. . . . co-founder of the company, 1921 . . . died April 16 . . . born 1868 . . .

ARMAN J. KEARFOTT . . . (M '27) . . . assistant department head, GM Research Staff, General Motors Corp. . . . had been with GMC since 1920 . . . died May 5 . . . born 1895 . . .

JOSEPH P. McGRAIL . . . (M '58) . . . chief draftsman, Midland-Ross Corp. . . previously associated with Allied Machine and Engineering . . . died March 31 . . . born 1912 . . .

EARLE W. PUGHE . . . (M '26) . . . consulting engineer . . . retired president of Ludlow Valve Mfg. Co. . . . died March 23 . . . born 1897 . . .

PERCIVAL J. TAYLOR . . . (M '30) . . . governing director, P. J. Taylor, Pty., Ltd., Sydney, Australia . . . died, April . . . born 1883 . . .

Rambling . . .

THROUGH THE

IF YOU HAVE TROUBLE

telling whether a car is coming or going — blame it on the ladies and the popularity of the "sack" dress. If the car's interior reminds you of an evening gown, that too can be traced to feminine preferences. Ford's executive stylist, Don De La Rosa, (above), told **MID-CONTINENT SECTION** ladies and gentlemen that auto interior designs are definitely influenced by women's clothing styles in color, pattern, fabric, and trim . . . and **Detroit's big problem** today is keeping pace with the "sack," and figuring out which way it is going!

• • •

Is it worth the required two billion dollars of taxpayer's money to go to the moon, when there is no economical or military advantage? **NEW ENGLAND SECTION** Speaker Robert F. Lybeck says, "No . . . what is needed is more than a giant step into space, it is a giant step into peace."

Lybeck suggests that we concentrate on more practical developments such as a chemical bomber, increased thrust through exotic and metallic fuels, nuclear propulsion, ion and photon rockets, and solar power.

• • •

Speakers at **WESTERN MICHIGAN** Student Night meeting were G. Waine Thomas, left, vice-president and chief engineer of Continental Motor Corp.'s automotive section; and Paul Allmendinger, right, assistant chief engineer of Stewart-Warner Corp., and SAE Student Activity chairman. Thomas discussed "Why Engineering?" with the students, and Allmendinger explained SAE opportunities for students and young engineers.

Discussing Planning for Progress Committee recommendations at **TEXAS GULF COAST SECTION** Governing Board meeting are, left to right, R. Frank Wilson, Section chairman; Charles Goff, Section secretary; R. B. Tuggle, Section Diesel Activity vice-chairman; and Ross Peterson, representative of the Planning for Progress Committee.

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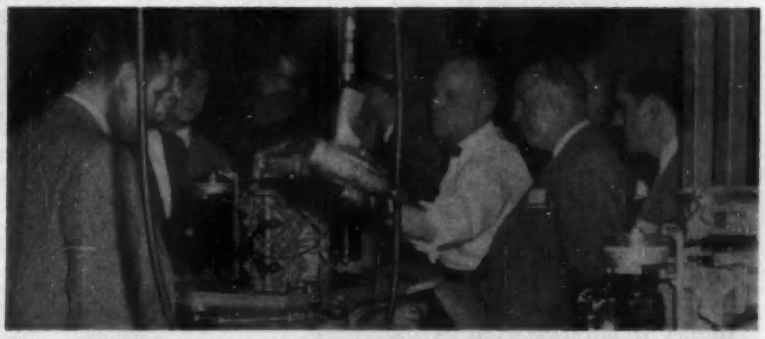


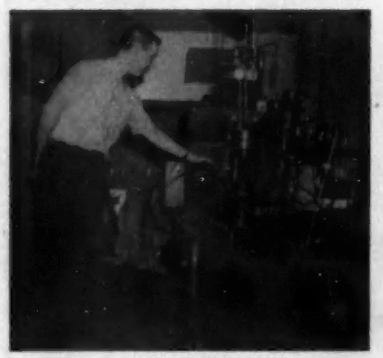
Members of the **MILWAUKEE SECTION** inspect connecting rods and crankshafts manufactured for Johnson and Evinrude engines. Two Evinrude motor plants were visited by the engineers in May.

SECTIONS

Who needs shock absorbers when riding on air? . . . Everybody, R. C. Cline told **ATLANTA SECTION**, since the new air suspensions can't eliminate body bounce and roll, wheel hop, and the need for human comfort. Requirements for shock absorbers will change with new suspensions, but Gabriel Co.'s research engineer insisted that shock absorbers are here to stay.

• • •

Because today's auto parts must be completely interchangeable, fitting perfectly for use in any assembly plant or service garage throughout the country . . . meticulous accuracy is required from the birth of a stylist's dream to a finished, functioning automobile. At **INDIANA SECTION** meeting in April, Bart Cotter, chief engineer of GMC's Fisher Body Division, traced an auto body from the drafting table to the test laboratory, stressing the new challenges to body engineering as new materials and processes are developed.



As part of Indiana Section's April meeting, members were conducted through Purdue University's Rocket Laboratory. (Above) a rocket motor and test apparatus are explained.

SAE National Meetings

• August 11-14, 1958, West Coast Meeting, The Ambassador, Los Angeles, Calif.

• September 8-11, 1958, Farm, Construction and Industrial Machinery, Production Forum, and Engineering Display, Milwaukee Auditorium, Milwaukee, Wis.

• September 29-October 4, 1958, Aeronautic Meeting, Aircraft Manufacturing Forum, and Engineering Display, The Ambassador, Los Angeles, Calif.

• October 20-23, 1958, Transportation Meeting, Lord Baltimore Hotel, Baltimore, Md.

• October 21-24, 1958, Diesel Engine Meeting, Lord Baltimore Hotel, Baltimore, Md.

• November 5-6, 1958, Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

• January 12-16, 1959, Annual Meeting, and Engineering Display, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

• March 16-18, 1959, National Passenger Car, Body and Materials Meeting, The Sheraton-Cadillac, Detroit, Mich.

• March 19-20, 1959, National Production Meeting, The Sheraton-Cadillac, Detroit, Mich.

• March 31-April 3, 1959, National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Commodore, New York, New York

• June 14-19, 1959, Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

• August 10-13, 1959, National West Coast Meeting, Hotel Georgia, Vancouver, B. C., Can.

• September 14-17, 1959, National Farm, Construction, and Industrial Machinery Meeting, Production Forum, and Display, Milwaukee Auditorium, Milwaukee, Wis.

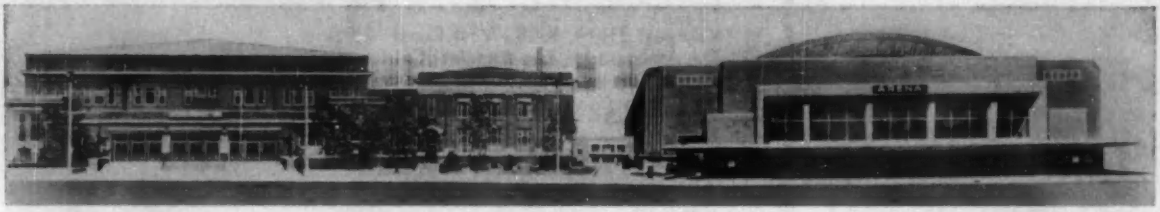
• October 5-10, 1959, National Aeronautic Meeting, Aircraft Manufacturing Forum, and Aircraft Engineering Display, The Ambassador, Los Angeles, Calif.

• October 26-28, 1959, National Transportation Meeting, La Salle Hotel, Chicago, Ill.

• October 27-28, 1959, National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

• October 28-30, 1959, National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

Milwaukee Meeting Comes of Age



. . . Presented for the first time are 61 engineering display booths and unlimited meeting facilities provided in the Milwaukee Auditorium pictured above.

TWO exciting new features are coming in September at the National Farm, Construction and Industrial Machinery Meeting . . . the Milwaukee Auditorium and an Engineering Display. Demand for an Engineering Display in Milwaukee sparked movement of the meeting to the spacious Milwaukee Auditorium, and 35 exhibitors have been accommodated. This display will permit all attending to actually see many developments described in the meeting's papers and to discuss them with company technical representatives at their exhibits. This meeting, held in Milwaukee annually for 22 years, last year attracted over 1700 top executives and engineers from the "off-highway vehicle" industries . . . representatives from the major manufacturers of farm, industrial, and road building equipment.

News . . . about forage harvesting . . . computer use in construction machinery design . . . production and design in the USSR . . . is promised at the six technical sessions, scheduled September 9 to 11, in addition to sessions on new trends and developments in many other areas.

The meeting will be launched September 8 with a Production Forum, followed by the meeting proper. Plans are being completed under the direction of Jack N. Yetter, general chairman of the meeting; L. E. Dondero, chairman, Production Forum; and Paul I. Birchard, sponsor, Production Forum. Sponsoring SAE Activities include Tractor and Farm Machinery, and Production . . . in cooperation with the Milwaukee Section.

SAE NATIONAL

WEST COAST MEETING

LOS ANGELES, The Ambassador

August 11-14, 1958

- 22 PAPERS
- YUMA TEST STATION FIELD TRIP
- BANQUET
- SESSIONS

heavy duty brakes and tires

powerplants

new research laboratory facilities

requirements for automotive fuels

heavy construction equipment

heavy duty automotive equipment

SPECIAL DEMONSTRATIONS . . .

. . . at Yuma Test Station planned for SAE National West Coast Meeting.

AN opportunity to inspect and observe special demonstrations of the Ordnance automotive equipment at the Yuma Test Station has been specially arranged for SAE members and guests as part of the 1958 SAE National West Coast Meeting. **In addition, it may be possible for the engineers to witness a test flight of an Honest John rocket.** Visitors will be able to watch demonstrations in desert environment of wheeled and tracked vehicles, ranging from the air-droppable Mechanical Mule to the 56-ton Heavy Recovery Vehicle. There will also be an opportunity to discuss the equipment and tests with Ordnance personnel.

This unusual and spectacular field trip has been made possible for SAE through the cooperation of the Office, Chief of Ordnance and the Commanding General, Sixth U. S. Army.

Also featured at this Los Angeles SAE gathering, August 11-14, will be six technical sessions with 22 paper presentations on ground vehicle problems, sponsored by four SAE Activities. Technical sessions will cover heavy duty brakes and tires, heavy construction equipment, powerplants, new research laboratory facilities, heavy duty automotive equipment, and requirements for automotive fuels. The program has been arranged under the leadership of Gilbert Way, general chairman of the meeting.

A banquet will be held August 12 featuring Ellis W. Spackman, chairman of Social Sciences of the San Bernardino Valley College and columnist for the San Bernardino *Sun-Telegram*, will speak on "West of Suez." R. Wayne Goodale, SAE vice-president representing Fuels and Lubricants, will be toastmaster. Provisions have been made, as part of the meeting, for visits to some of the new refineries and research centers in the Los Angeles area; and several functions have been scheduled for the ladies.

Ways Sought to Cut Throttle Deposits

Based on paper by

K. B. VALENTINE
Pontiac Motor Division, GMC

MANY recent stalling troubles are directly traceable to throttle deposits. Recent engine and styling changes in passenger cars have made these deposit formations at the throttle bore of increasing importance. A deposit of even 0.02-in. thickness — which has happened in 5000 miles of operation — can cause a car owner considerable trouble.

Reports of throttle-deposit stalling show occurrence with both 2- and 4-barrel carburetors; with carburetors of totally different design; on cars with only 5000 miles of driving . . . with reoccurrence in 300 miles regardless of carburetor parts used . . . and with most brand-name gasolines sold in the East and the Midwest.

An extensive Pontiac test program aimed at better understanding of these throttle deposits and their results developed at least four ways to alleviate them.

1. Use of fuel additive: A fuel additive (currently being distributed in the California area) was blended with a gasoline used by one of our customers who was having considerable trouble. The customer used this blend for 5500 miles and no deposits formed. Without the use of this additive, critical deposits formed at about every 1000 miles of driving. One car of our test fleet, which had formed a moderate deposit, was switched to gasoline blended with this additive. The quantity of deposit did not increase in 550 miles driving.

These performances indicate that properly blended fuel can prevent detrimental deposits from forming.

2. Bypass idle air carburetor: The use of this system does not inhibit the formation of deposits but only alters the critical surface area upon which deposits are formed.

3. ⅛-in. holes in primary throttle valves: Holes drilled in throttle valves preclude necessity of maintaining opening between valve and bore. The engine air requirements at idle can be satisfied by air passing through the holes in the valves. Some evidence available indicates this change in airflow inhibits formation of deposits on the bore at the throttle valve area.

4. Electric fuel pump and electric windshield wiper: Use of this equipment increased mileage prior to critical deposits formation. Operation of this type of equipment does not admit additional air to the throttle body. Therefore, less airborne dirt is introduced into the system.

An additional item which may have beneficial effects upon deposit formation is the dry-type air cleaner with inlet forward. Our car testing of this item was inconclusive but some positive results were obtained.

Investigation also indicated that gasoline was a major factor affecting deposit formation. Differences in gasoline available in California as compared to elsewhere, for example, are a major item in restraining critical deposits in cars operated in that state.

Last July, a comprehensive analysis of gasolines available in the Detroit area failed to reveal — at least to Pontiac engineers — any significant factor relative to deposit-forming propensity. Laboratory tests failed to confirm the suggestion that residual materials in gasoline tank, fuel lines, and the like were contributing to throttle-deposit formation.

Design changes in 1958 which have proved beneficial in alleviating deposits include changes in air cleaners, battery location, de-icer heat, bypass idle air, and use of an antistall device. But such factors as air temperature and airborne dust are not affected by the design changes made for 1958 . . . nor by changes contemplated for the immediate future.

The major factor of gasoline composition, however, does offer a positive means of eliminating the detrimental effects of temperature and dust.

To Order Paper No. S69 . . . on which this article is based, see p. 5.

Simplicity Features Ground Speed Indicator

Based on paper by

J. R. IVERSON
Ryan Aeronautical Co.

THE Ryan model 114 ground velocity indicator, one of a family of lightweight, Doppler-type indicators, features:

- Continuous wave radar transmission.
- A fixed-mounted antenna.
- Two radar beams.
- *K*-band operation.
- Direct-to-audio detection.
- An a-c analog computer for Doppler data stabilization.

Continuous wave transmission is used in preference to the pulse-type radar because it is simpler, more direct, and more reliable in design. There is no

need for a transmitter modulator, T-R devices, ferrite isolators, complex waveguide systems, or special circuitry.

The major advantages of the fixed-mounted antenna in contrast with the mechanically stabilized type are higher reliability, lower installed weight, smaller cutout area, and lower swept volume. It has no moving parts and requires no adjustment after installation.

Two nonstabilized radar beams are the minimum required for a ground velocity indicator. Using two beams rather than three or four results in the smallest cutout area, least volume, and minimum equipment.

One advantage of the K_a-band frequency over the X-band lies in getting an equivalent system performance with a smaller antenna. Many existing radar systems operate at X-band, hence the possibilities of interference or crystal burnout near airfields and in crowded airways may be high.

With direct-to-audio detection, the receiving energy is mixed directly with a portion of the transmitter energy, which yields the Doppler signal directly. The technique is extremely simple.

An a-c analog computer was selected in preference to all mechanical or digital types because of the simple, straightforward solution of the required equations. Moreover, the outputs are in a form suitable for direct use in accessory equipment. This type is less costly, lighter, and easier to maintain.

To Order Paper No. 40A . . .
on which this article is based, see p. 5.

How Five Companies Organized for Automation

Based on secretary's report by

H. E. WOLCOTT

A. O. Smith Engineering Service Corp.

ORGANIZING for automated assembly programs is a problem that can be worked out in various ways to best mesh with the particular size and organizational characteristics of the company concerned. Here's how five different companies approached the problem.

One large company that had decided, at a policy-making level, to make the utmost of the opportunities offered by automation concluded that its success would most likely be insured by setting up a separate central group, aside from the regular processing group but on the same level, whose specific assignment was to be the pursuit of automation applications.

This approach was felt to insure a breadth of knowledge and experience being brought to bear on the program that might not otherwise be available if a process engineer were to handle each undertaking singly as a project.

All such programs were routed through the special group for review of layout, work standards, methods, and the like.

Later on a similar special automation group was established for each division with the company. As part of its activity, this special automation group established a piece cost for the conventional processing method to which was compared the estimated piece cost for the automated method. The finance people were active in the decision-making to insure reasonable payout as viewed from all financial and tax aspects.

Without such careful cost and financial comparison of the conventional and automated methods this company feels the probability of making correct decisions is questionable.

Company No. 2 feels that integrating parts for automated assembly should be preceded by integration of the organization charged with execution of the program; that is, such functions as product design, tool design, plant layout, and equipment design must be headed up by a responsible leader in order to keep the various functional group leaders working in an integrated manner toward the same final objective.

Company No. 3 says that sizable automated assembly programs can be executed with the regular processing and manufacturing engineering groups and quite satisfactory results obtained.

A fourth very successful automation organizational setup has to do with a company manufacturing and assembling relatively small parts wherein there is a small separate group working in an automation assembly laboratory. Mock-ups of the installation are made, followed by actual setup of the assembly machine and fixtures in the laboratory area. Shop people are brought in for advance information and suggestions prior to installation in the operating area. This proves to be an effective procedure in selling the group which will ultimately be operating the equipment.

Obviously this is a method which, though satisfactory for automated assembly of small parts, is limited in application as parts and processes increase in size.

The fifth company revealed that based upon experience with a several hundred foot automatic assembly line for large, flexible components, the transfer mechanism would, in retrospect, be made longer to accommodate more manpower initially, and individual assembly station machines and fixtures would be developed off the assembly line and moved in place on the line as perfected; the operation in the meantime being handled with additional manpower and conventional tools and equipment.

The single long-line approach was carefully studied as compared with one whereby the single long line would be broken up into four or five lines. The latter was decided against since, among other considerations, additional manpower and in-process inventories would be designed into the basic system.

In addition to the panel secretary, others serving on the panel which developed the information in this article were: **D. W. Sherman**, A. O. Smith Engineering Service Corp.; **W. R. Griswold**, A. O. Smith Engineering Service Corp.; **T. R. Timm**, General Motors Corp.; **A. M. Barrett, Jr.**; Barrett-Cravins Co.; **G. Swardenski**, Caterpillar Tractor Co.; **D. R. Bell**, General Motors Corp.; and **J. McDougall**, Ford Motor Co.

To Order SP-322 . . .
on which this article is based, see p. 5.

Nuclear Submarines

Based on talk by

JOHN L. HELM

Electric Boat Division, General Dynamics Corp.

(Reported by R. S. Karlson, SAE Southern New England Section Field Editor)

THE basic powerplant being used for submarines is similar in most respects to the Shippingport reactor.

It is surprising to note that of the total money spent on the project, only about 10% has been expended on physics, with mechanical engineering accounting for 38%, electrical — 30%, and the remainder of the funds spent on chemical and metallurgical engineering. The reactor itself is a huge, stable, controllable heat source. The biggest problem is to transform this heat into power. This is done by the use of a basically conventional steam plant. A coolant flows through the reactor core, transfers heat to the heat exchanger, where water is boiled to produce steam. The steam is eventually used in a conventional-type turbine to produce motive power. The system is not operated at the highest temperatures and pressures now being used in conventional steam plants, due to the fact that the reactor cannot be as hot as a gas or other type of furnace.

The reactor, of necessity, has structural members (fuel elements, for example) directly in the heat zone, which

Safe Pilot Ejection Level Drops to 500 Ft

Based on paper by

JOSEPH H. DRESSEL
Bureau of Aeronautics

(Presented before SAE Metropolitan Section)

LOW-SPEED ejection fatalities have affected the design of airplane seats and controls. Now the pilot moves one control and the ejection seat automatically throws him into the proper parachute descent at low or high altitude.

Bailing out under 2000 ft resulted in death 50% of the time when the pilot first had to release the canopy, then fire the seat, release himself from the seat, and pull the rip cord. The death rate climbed to 75% for jumps under 1000 ft.

The Martin-Baker seat adapted by the Navy now provides safe bail-out from altitudes of 500–700 ft, straight and level. It does this by:

- A single pilot escape motion, either by his pulling down the face curtain or, in case he can't reach it, tripping a control at the front edge of his seat.
- Firing three cartridges automatically for a smooth ejection motion with a peak velocity of 83 fps.
- Release of the canopy automatically or breaker points on the seat for canopy "crash-through."
- A self-fired drogue gun to deploy a 22-in. seat parachute ½ sec after the three cartridges fire.
- A second 60-in. parachute pulled out by the first one to decelerate the pilot and seat for 1¼ sec or until he is at an altitude safe for extending the main chute.
- Leg straps that keep the pilot's legs from flailing until the pilot and seat are separated.
- Automatic lap belt release that lets the pilot and seat separate. At the same time the leg straps disconnect.
- After seat separation the two drogue chutes pull out the pilot's main chute.

This rapid low-level ejection system has a barometric and speed limiter to prevent parachute failure. The barometric control prevents pilot-seat separation above 10,000 ft. The speed limiter is actually a "g" meter, which delays the pilot's chute from opening until his deceleration rate drops below the safe value for the chute. These provisions make the system safe for normal flight bail-out.

To Order Paper No. S86 . . .
on which this article is based, see p. 5.

Feature the Shippingport Type of Powerplant

cannot withstand the same temperatures as the tubes in a conventional boiler, which are cooled on one side. There is also the problem of having a more corrosive atmosphere and the presence of radiation damage in the case of the nuclear reactor. Since the reactor-powered submarine does not have to carry large tonnages of fuel, the lower efficiency caused by lower pressures and temperatures is not too serious a problem. Especially in Naval service if the craft can be made light, small, and fast, the efficiencies of the powerplant are secondary.

Submarine Construction

The nuclear ship is considerably different from the conventional submarine, in that there are many large parts that cannot be efficiently spread out, due to the difficulty of running long, large diameter steam lines. The new hulls are larger, with varying cross-section in order to accommodate the nuclear powerplant. Some parts of the hull are double in order to effect an overall streamline shape. The necessity of having the steam plant, turbine, and condenser all in one place presents severe space, weight, and balance problems. Heavy shielding necessary for the reactor itself adds to the designers' problems.

Actually, the submarine hull has had to be completely redesigned to accommodate the necessary shape of the new type of powerplant. An interesting item in conjunction with the overall design is the fact that by adding one pound to the weight of the powerplant it is necessary to add 5–7 lb to the overall weight of the ship in order to keep balance and contour under control. Similarly, if the position of the center of gravity of the plant is moved 1 ft, the diameter of the hull must be increased approximately 2 ft in order to keep the unit in balance. Final design of all components is a constant compromise to achieve the best overall performance.

Powerplant Systems for Submarines

The steam plant must be *absolutely* leak proof in order to keep the atmosphere in the hull habitable both from a humidity and radiation standpoint. In this respect all the valves, controls, and so on, used in the system are special and incorporate seal welded joints. The pumps incorporate canned rotor motors and again are welded shut. Stainless steel is used extensively.

The reactor is a light, water-cooled and moderated, thermal unit. Fission neutrons are slowed down by the water to thermal speed in order to maintain the reaction. The reactor is inherently stable, as when the coolant is heated it expands, the hydrogen atom density decreases, less neutrons are slowed down by collision with the hydrogen atoms, causing less fissioning and reducing power. The resultant radiation level in the submarine when operating is below the normal exposure on the earth's surface.

Many of the design problems associated with projects of this type could not have been solved in time to be of use without the aid of modern electronic computers. By the use of these devices it is possible to "try" many test setups very quickly and only build the one which shows the best promise of success.

In order to control the reactor output and also prevent the possibility of a "runaway," together with the release of destructive radioactive products, the reactor is equipped with control rods. These are mechanically controlled rods of material which has a high absorptive cross-section to thermal neutrons. These rods are lowered into the pile to reduce output and raised to increase output. Neutrons are absorbed by the control rod material and thus cannot cause fission of the fuel elements. In the case of an emergency the rods can be "scrammed" in a fraction of a second to completely shut down the reactor.

Nuclear submarines now under construction will be capable of long, high-speed runs under the water and can be used for mobile missile launching areas which may be positioned anywhere in the world, from under the arctic ice pack to the depths of the Red Sea.

How Heat Flows from Solid Exhaust Valves

Based on paper by

J. M. CHERRIE
and
M. J. TAUSCHEK
Thompson Products, Inc.

(Presented at SAE Cleveland Section)

THE popular conception that solid exhaust valves are cooled primarily by conduction down the stem is not true. Fig. 1 shows temperature measurements made on the cross-section of a valve to determine the path of heat flow. The solid lines are isotherms and the dotted lines the heat-flow paths.

Many of the heat-flow paths leave the valve at the face. In fact, considerably over one-half of the total heat absorbed by the valve leaves the valve through the face. Thus the importance of the valve face and seat in cooling the valve cannot be overestimated.

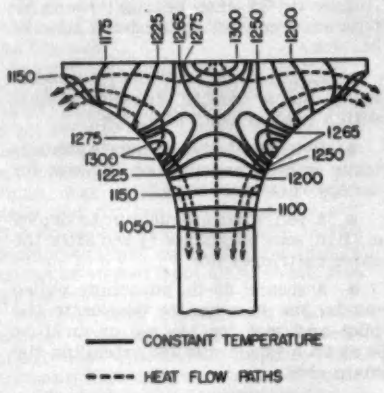


Fig. 1 — Diagram of heat flow in exhaust valve shows that over half the total heat leaves the valve through the face.

To Order Paper No. S88 . . . on which this article is based, see p. 5.

Higher Power Outputs Accentuate Wear Problems

Based on paper by

R. L. PONTIOUS
Sinclair Research Laboratories

(Reported by Gilbert K. Brower, SAE Chicago Section)

RECENT changes in design and performance requirements associated with the trend to higher power outputs have accentuated wear problems in modern engines. They have also stressed the need for development of suitable lubricants to prolong the useful life of these engines.

Modern engines have presented a variety of critical wear problems. Corrosive, abrasive, and frictional wear of piston rings and bearings has been described in the literature. Valve train wear is a major problem. Stop-and-go driving and high-speed toll road operations also adversely affect engine component wear. The need for better motor oils has necessitated the development of better wear for predicting lubricant performance. Wear is determined directly by physical measurements (micrometry and gravimetry) of worn parts and by indirect measurements of material worn off a radioactive engine component. Both of these general methods are necessary for a comprehensive evaluation of modern engine lubricants. Many test techniques are used in determining wear.

But short-term screening tests must also be developed to provide reliable wear data on the various components or additive combinations of lubricants prior to full-scale evaluation. Wear studies of different irradiated engine parts appear to fulfill this requirement. Extended service-type engine tests also must be run under realistic road operating conditions as part of the final proof testing of a finished lubricant.

To Order Paper No. S103 . . . on which this article is based, see p. 5.

Cost Control Needs Supervisor-Employee Aid

Based on secretary's report by

ROBERT M. LYNAS
Thompson Products, Inc.

ADEQUATE organization is essential to a cost control program because of the need to establish and clarify duties and responsibilities, particularly those which relate to costs and performance. Cost controls are synonymous with profit planning. The successful cost control program is only as sound as the understanding of the reason for its existence and the top management support it obtains. Cost controls should be made a functional part of management and responsibilities limited to an area within the normal management boundaries of each supervisor.

Winning the Support of Supervision and Employees

Giving adequate organization, winning the support of supervision and employees is primarily a matter of communications. Good communication is vital to an effective cost control program. The following from the basis for the communications network:

1. Informed, capable management.
2. Alert, responsible supervision capable of understanding objectives.
3. Planned program for accumulation and dissemination of cost data.

The mechanics of winning support from a willing supervisory group are:

1. **Establish Objectives** — Have the supervisory group participate in setting realistic objectives and make sure they clearly understand the methods used to develop their goals. Make the individual aware of his responsibilities.
2. **Offer a Challenge** — Supply facts for comparison with past achievements and make sure the supervisor is competing against his own record rather than total plant or other sections.
3. **Publicize and Review** — Get figures as current as economics permit, review responsibility levels with supervision, and have them plan any corrective action needed.
4. **Follow-Through on Corrective Action** — Give the supervisor assistance in correcting problems beyond his control.

The mechanics of winning the support of employees are:

1. **Personal Contact** — Know the man and his interests.
2. **Commend Good Performance** — Develop pride of workmanship.
3. **Ask for Suggestions** — Adopt those that are good and explain why others are not usable.
4. **Develop Group Interest** — Stress quality and quantity to weed out misfits.
5. **Use Displays** — Such as broken tools, cost of tools, performance charts, to get a point across.

Translating Reports into Effective Action

Control of costs is dependent upon the action taken. Adequate, timely reports will direct management's attention to phases of the business requiring attention.

Energy should be directed to the largest cost areas. In an incentive shop, high performances are checked as carefully as low performances against a standard. The variances are analyzed for corrective action.

Indirect and direct department budgets are established for each department by the foreman, with the assistance of an accountant and an industrial engineer. This approach has the foreman taking a major part in setting his

New Truck Chassis Meets Challenge for More "Cube"

Based on talk by **W. E. PETERSEN** International Harvester Co.

(Presented at SAE New England Section)

Fig. 1 — IHC Sightliner tractor features 48-in. bumper-to-back-of-cab dimension.

THE Sightliner (Fig. 1), with 48-in. bumper-to-back-of-cab dimension, is International Harvester's answer to the truckers' cry for more "cube." (This word refers to the fact that many operators have been running out of cargo space before reaching legal weight limits, particularly in tractor-trailer operation.)

Engineering investigation determined that 48 in. would be the shortest dimension that could be used and still provide comfortable and efficient room for an adult driver.

The possibility of developing a chassis with the 48-in. dimension was largely predicated on the fact that short V-8 engines of sufficient power were already available in the line of products.

A complete new cab design was required. Wide doors were provided for easy access. A smooth interior and a 3-way adjustable seat (Fig. 2) were designed for driver safety and comfort.

To attain the 48-in. dimension it was necessary to mount the cab above the engine. This posed two problems: near vision and service access to the engine. With the driver riding high, his vision over the traffic was excellent. The problem of the driver being able to see directly in front of the truck was solved by providing two lower windshield glasses in the front. Easy service access to the engine was obtained by providing the electrohydraulic mechanism (Fig. 3) that tilted the cab forward in less than 15 sec. For safety, a release lever was provided that had to be used before the cab was tilted. The mechanism was designed to lock the cab in place automatically when it was lowered.

Fig. 2 — Interior of Sightliner cab. Note wide door for easy access, smooth interior, and 3-way adjustable seat.

Fig. 3 — Electrohydraulic mechanism tilts cab forward in less than 15 sec.

With the solution of these and a multitide of smaller problems, we were able to announce a new chassis with a 48-in. bumper-to-back-of-cab dimension in regular production that can be used to advantage anywhere in the U. S.

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goals. Analysis work to help the foreman to meet his budget is done by the foreman and industrial engineer.

These budgets and standards are translated into effective action through analysis of variances, follow-up, and cost control meetings held weekly by the superintendent.

A cost control program can point out areas where improved methods are needed. To reduce costs through improved methods, it is necessary to get the facts. To arrive at a good justification for changing the present method, the potential of the present method must be determined. This approach may point out that the potential of the present method is not being used and cost reductions can result without further investment.

In addition to the panel secretary, others serving on the panel which developed the information in this article were: **C. W. Goldbeck**, Thompson Products, Inc.; **W. Kobylarek**, Bendix Aviation Corp.; **E. A. Wells**, International Harvester Co.; **J. F. Biggane**, Maytag Co.; **C. A. Nichols**, General Motors Technical Center; and **P. H. Neville**, Leece-Neville Co.

To Order Paper No. SP-322 . . . on which this article is based, see p. 5.

Solar Battery Heralds Sun-Power Age

Based on talk by

RALPH T. RIEFENSTAHL
Ohio Bell Telephone Co.

(Presented at SAE Dayton Section)

THE solar battery is simple in construction, produces about 1½ v of electricity when exposed to light, and can be made a very practical tool by harnessing it to a storage device which will serve as a power source during periods of darkness. It marks the first successful attempt to convert light into electrical energy efficiently and seems destined to have a terrific impact on our way of life.

Silicon is the basic ingredient of the battery. It is refined until practically pure, in which state it costs $380 per lb. It is then doped with a very small amount of arsenic and cut into cells about the size of a 25¢ piece. One side of each cell is exposed to boron gas until infused to a depth of 0.0001 in. After wires are attached, linking the cells together, the unit is encased in plastic or glass for easier handling.

Germanium has also been investigated as a possible battery material. Germanium is the heart of the transistor and it was the research and development making this device a reality which led to the invention of the solar battery at the Bell Laboratories. A transistor and a solar battery will probably be used together very often since the former operates on minute amounts of power which can be supplied by the battery.

The solar battery now operates at an efficiency of 11% and a rise to 22% is foreseeable. This may seem small but 11% is more than can be obtained from a steam locomotive or automobile engine.

The first practical application of the solar battery has been in rural telephone service. An experimental installation has been made near Americus, Ga., using the "carrier" principle, which allows several conversations to be sent simultaneously over a single pair of wires. Since each conversation is sent at a different frequency, there is no interference. Transistor repeaters or amplifiers are mounted on telephone poles to boost the voice currents. Atop the pole is a solar battery which furnishes power direct to the repeaters. Excess current feeds into a storage device which provides power at night and over periods of bad weather.

The battery has no moving parts or corrosive chemicals and should last indefinitely unless damaged by stone-throwing boys or smirched by ill-bred birds. Even in poor light it will continue to charge the storage unit, but at lower power. While it will benefit the telephone business, its greatest contribution probably will be to the arid regions of the world where power sources are scarce.

Gasoline, F-P Engines Gas Turbine Compared

Based on talk by

JOHN S. WINTRINGHAM
Ethyl Corp.

(Presented before the SAE Baltimore Section)

GAS TURBINES and free-piston engines do not yet attain the fuel economy of the gasoline engine, but they do have certain other advantages. For instance, their transmission requirements are much simpler.

Table 1 compares the three types of engines for use on passenger cars, in terms of which is simplest, cheapest, or least restrictive.

Fig. 1 compares the fuel economy of a passenger car propelled by gasoline engine, gas turbine, or free-piston engine. The curve for the gasoline engine represents actual data on a 300-hp car. The two unconventional engines represent calculations made by the author's company to provide similar performance.

The fuel economy data are approximate indications of fuel costs per mile, since fuel for either unconventional engine would cost almost as much as gasoline, if it were distributed as widely and carried similar taxes.

Table 1—Balance Sheet

	Advantage Appears to Lie with		
	Gasoline Engine	Gas Turbine	Free-Piston Engine
Transmission	2	1	1
Control	1	2	3
Acceleration Lag	1	3	2
Fuel Quality	2	1	1
Fuel Economy	1	3	2

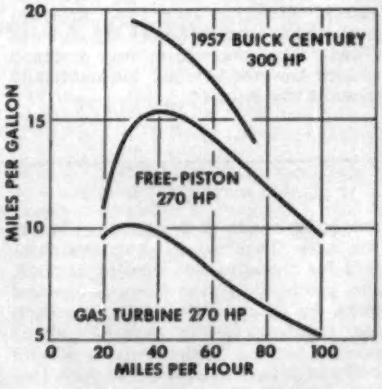

Fig. 1—Gas turbines and free-piston engines are not yet able to give as high fuel economy as the gasoline engine.

Unitized Design Adapted to Low Cars

Based on paper by

H. W. JOHNSON
Ford Motor Co.

(Presented before SAE Detroit Section)

UNITIZED body design is well adapted in general to increasingly low car designs. In a few respects, however, positioning of units is more difficult. Here are some examples:

- Spacious footwells can be made available in the floor pan. With no frame side rails to consider, narrow sills — and consequently wide footwells — can be used.
- Increased stub pillar rigidity is possible, because the designer can take full advantage of the strength of the frame for maximum pillar rigidity. (On a 4-door Lincoln hardtop with unitized body, the stub pillar is 65% more rigid in longitudinal section and 38% more rigid laterally than in the previous Lincoln with conventional frame.
- The relatively smooth underbody of a unitized body makes it more difficult to provide an effective exhaust component location.
- Physical limitations in the kickup areas are also restricting factors.
- Closer engine-to-sheet-metal clearances are possible, since the usual tolerance stack between frame and body is eliminated.

To Order Paper No. S92 . . . on which this article is based, see p. 5.

Outboard Motor Builders Face Many Tough Problems

Based on paper by

W. C. CONOVER
Outboard Marine Corp.

(Reported by Gilbert K. Brower, SAE Chicago Section)

WE NEED better cooperation between outboard motor builders and the petroleum industry. Many frustrating problems have plagued the engine

Continued on page 124

New extreme-high-temperature lubricants for missiles and supersonic aircraft **SHELL ETR GREASES**

One of the serious lubricating problems faced by designers of missiles and supersonic aircraft has been solved by scientists at Shell Research Laboratories.

The problem: to find a grease which would permit components to operate with certainty under extreme high temperatures. Co-operation with representatives of bearing manufacturers and military personnel resulted in a completely new class of greases—SHELL ETR GREASES.

These greases can easily withstand temperatures up to 600°F. They give superior lubricating performance because of a special thickener—an organic vat dye—which has exceptional heat stability and jelling efficiency.

If you are presently in the market for an ultra-high-temperature-range grease, we will be glad to provide more information on Shell ETR Greases.

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Applied Research in Radome Development, Antenna Development, Infrared, and Acoustics.

Please write to: Mr. G. G. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

Continued from page 122

builder. Research and development in an area that is beyond the scope of normal engine development need further recognition.

Just 87.9% of all power boats in the United States are powered with outboard motors. In 1957 these boats consumed 259,000,000 gal of gasoline and 13,000,000 gal of lubricating oil.

Many problems require cooperative action to solve. For instance, in the early days of the outboard motor industry, all lubricating oils were of the straight mineral type. With the advent of additive and detergent oils for the automotive industry, detrimental effects on spark-plug life in two-stroke engines were encountered. Unfortunately, specifications that would constitute a satisfactory standard to which oils should conform have not been established by either the engine builders or the oil refiners. This should be the first major objective of a cooperative program.

Properties that a good outboard motor oil should have include: good mixing ability with fuel; high-temperature film-strength; reduction of deposit-forming tendencies associated with pistons and ring, the combustion chamber, and spark plugs; residual anti-corrosion characteristics; and avoidance of additives damaging to rubber parts. In addition the gasoline should have good storage stability and additives inserted to reduce the adverse effects of leaded fuels.

To Order Paper No. S101 . . . on which this article is based, see p. 5.

Turbines are Tops For Small Boat Power

Based on paper by

JAY S. PASMAN

U. S. Naval Engineering Experiment Station

(Presented at SAE Baltimore Section)

POWER output for its size is the most conspicuous advantage brought by each of the 288 gas turbines currently installed in 133 different craft by the U. S. Navy. As of last November 1, these units had compiled a total of 67,476 hr — and 81 more such engines were on order for installation in as many additional boats. . . . The small, open-cycle gas turbine is well established — after 8 years of testing — as a prime mover in marine service.

These engines generally run between ¼ and 1/10th the weight and ½ to ¼th the volume of reciprocating engines. Besides, each one is a complete package containing all accessories and auxiliaries, whereas other types of prime movers usually require separate pumps, coolers, and associated plumbing. . . . In two patrol boats, where the Navy installed gas turbines in the same space from which other-type engines had been removed, the shaft power was tripled and the boat's speed doubled —

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Call on the swiftest planning-to-production service in the wheel industry today.

Call an ELECTRIC sales engineer. Enjoy quick answers to all your questions, prompt help with a new design or cost-cutting suggestions for a redesign.

Enjoy, too, the follow-through that only ELECTRIC's automated operation, ideal location and years of agricultural and industrial experience can give you.

Call or write today for the exact disc or spoke-type wheel (steel or rubber-tired), rim, hub, axle or component part you want—when you want it.

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During our more than 45 years of service to the Automotive Industry, parts by "Cleveland" have served and are still serving many manufacturers whose products have won world-wide acclaim. We are proud of the part we have played in their success and proud of the reputation for reliability and ruggedness which "Cleveland" parts have won with our manufacturing customers.

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from 12 to over 25 knots.

Gas turbines provide spectacular improvement over reciprocating engines in cold-weather operation, too. The gas turbine starts as easily in cold as in warm climates — because it has much less bearing area and doesn't rely on the temperature of compression for ignition. This holds true under arctic conditions as low as – 65 F. Besides, the gas turbine can carry full load immediately with no required warmup time or danger of stalling-out. In addition, gas turbine power output rises sharply as the air becomes more dense due to cold.

Considerably reduced vibration is characteristic of gas turbine performance in the Navy applications due to the shaft motion being solely rotary. This spells greater reliability, because split-shaft units all contain inherent torque characteristics without the addition of a separate transmission.

This solely rotary shaft motion is important in applications such as retracting a beached landing craft under its own power . . . where the propeller frequently gets stalled in sand or mud. Under these circumstances, the gas turbine supplies double the full-rated torque to the output shaft, as compared to the reciprocating engine, which would stall out.

This higher torque characteristic also can be important in electrical generator sets during sudden applications of heavy loads. This, plus a low magnetic signature makes the gas turbine ideally suited to mine-sweeping operations.

Other Navy applications where the gas turbine has been found advantageous include electrical power generators, large volume air compressors, fog-generator for laying smoke screens, de-icing ships on arctic expeditions, using exhaust gases to cool the engine compartment with no additional power drain, driving a water pump for fire fighting, and emergency water-removal from flooded bilges.

Since 1950, when gas turbine powerplants first began to be tested at the U. S. Naval Engineering Experiment Station at Annapolis, much experience has combined to show that the versatility of these units more than offset their higher costs in many applications . . . and that their many advantages outweigh some of their basic disadvantages.

To Order Paper No. S87 . . . on which this article is based, see p. 5.

the best costs less

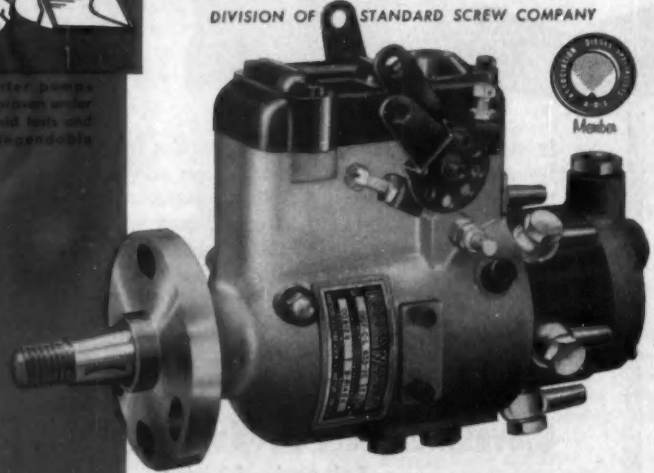
Simplicity is the word for ROOSA MASTER fuel injection pumps. Small in size and weighing less than 10 pounds, there are fewer parts to service, fewer adjustments, which means lower service costs.

Only one model size is adaptable for either a 2, 3, 4, 6 or 8 cylinder engine. Compare its initial cost and installation cost for further proof that the best costs less.

HMS ROOSA MASTER makes good diesels better

HARTFORD MACHINE SCREW CO., HARTFORD 2, CONN.
DIVISION OF STANDARD SCREW COMPANY

Roosa Master pumps have been proven under extensive field tests and years of dependable service.



YOU CAN DEPEND ON THE DIESEL THAT DEPENDS ON ROOSA MASTER

4 Ways to Reduce Casting Tolerances

Based on secretary's report by

S. C. MASSARI
American Foundrymen's Society

THE present tendency on the part of the purchaser of castings is to demand increasingly closer dimensional tolerances and machine allowances as a means of decreasing machining costs. The amount of finish allowance required is primarily dependent upon the size of the casting, the method of molding, accuracy and design of the pattern equipment, and the complexity of the part involved.

Basic suggestions which are offered as means to reducing casting tolerances are:

1. Specify close tolerances where only absolutely necessary.
2. Allow clearance in design for normal casting variables.
3. Maintain close liaison between foundry and casting user before casting design is established.
4. Follow-up on machining and assembly problems when first castings are being processed.

In addition to the panel secretary, others serving on the panel which developed the information in this article were: **H. Bornstein**, consultant; **T. E. Barlow**, International Mineral & Chemical Corp.; **F. W. Carl**, General Motors Corp.; **T. W. Curry**, Lynchburg Foundry Co.; **R. L. Gilmore**, Superior Steel & Malleable Castings Co.; **W. D. McMillan**, International Harvester Co.; and **H. G. Sieggreen**, General Motors Corp.

To Order Paper No. SP-322 . . . on which this article is based, see p. 5.

XXVIII

This is the twenty-eighth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Cold-Finishing of Alloy Steel Bars: Turning and Polishing

Continuing our discussion of the cold-finishing of alloy steel bars, we take up the subject of turning and polishing. A later discussion will cover grinding and polishing. Both require removal of surface metal. In both the turning and grinding operations, adequate allowances provide for the removal of decarburization and surface defects which sometimes occur in alloy bars.

As previously stated, the outstanding advantage of cold-drawn bars over hot-rolled bars is the *bright, smooth finish*. However, the quality of the cold-drawn finish varies with the size and amount of draft (reduction of cross-sectional area) applied in cold-drawing. For example, by using a 1/16-in. draft, a 3/4-in. round would have a better cold-drawn finish than a 3-in. round.

When a superior mirror-like finish with additional accuracy is required on surfaces that are not machined (such as on shafting or machine parts), two processes other than cold-drawing are suggested: turning and polishing, and grinding and polishing. The first of these will be discussed here.

Turning and Polishing. This method of cold-finishing is generally associated with centerless bar-turners, accommodating rounds from 1 1/4-in. to 6-in. diam, inclusive. The process is the reverse of conventional lathe-turning, which is normally used for larger sizes. The centerless turning equipment uses two cutter heads which contain from one to four cutting tools. The system provides for both rough and finish cuts. The bar, which is stationary, is fed horizontally into the rotary cutter heads by means of a mechanical or hydraulic feeding mechanism. Most bar-turners are equipped with a series of polishing rolls that also rotate around the bar as it feeds from the rotary cutter heads. This, combined with subsequent burnishing action from the straightening rolls, imparts a high degree of polished finish to the product. A polished surface on a turned bar can also be produced by a number of passes through the straightening rolls.

This process is applicable to normalized, annealed, or heat-treated carbon and alloy bars. It does not materially affect the mechanical properties. For this reason, the end product can be machined unsymmetrically, with little or no tendency to warp.

Bethlehem metallurgists will gladly work out any problem in the cold-finishing of alloy steel bars. Always feel free to ask for their services.

When you are in need of steels remember, too, that Bethlehem manufactures the entire range of AISI standard alloy grades, as well as special analysis steels and all carbon grades.

If you would like reprints of this series of advertisements, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The subjects in the series are now available in a handy 40-page booklet, and we shall be glad to send you a free copy.

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On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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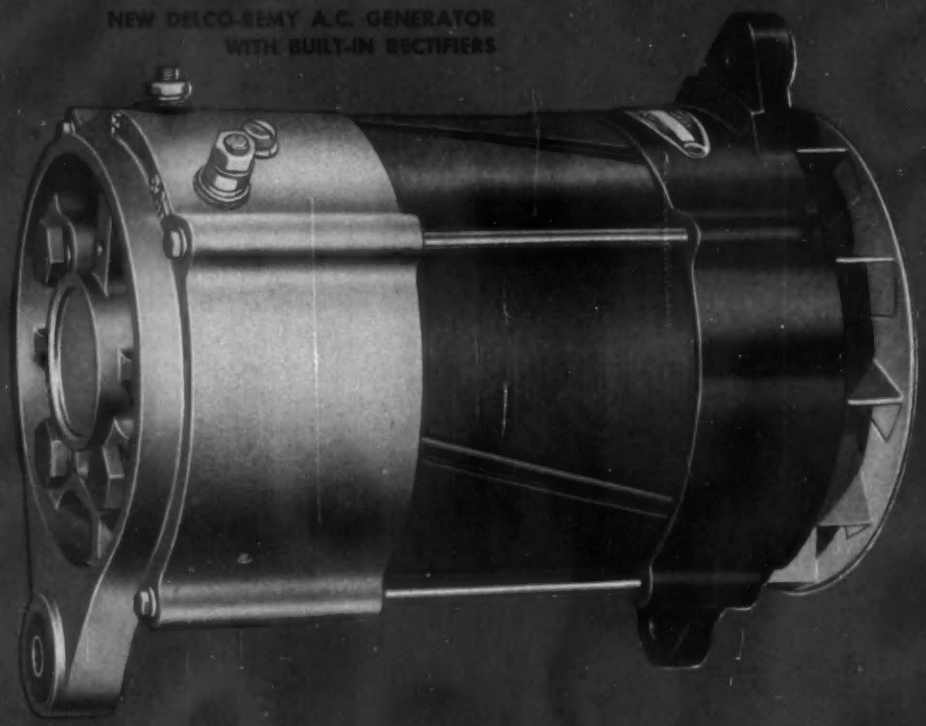
WITH BUILT-IN RECTIFIERS



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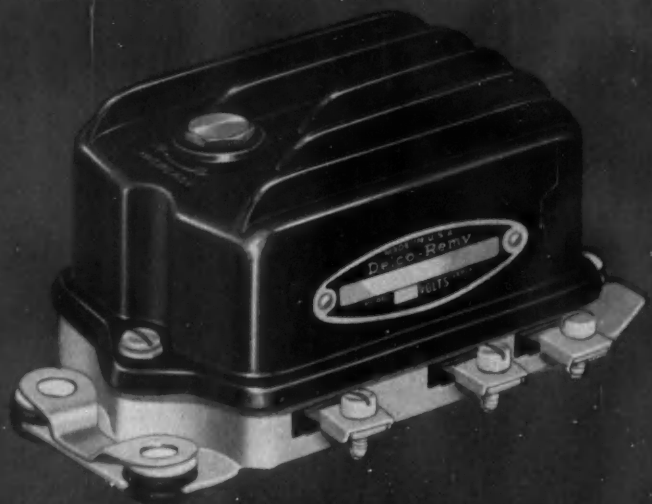

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—DELCO-REMY'S NEW GOLDEN MILESTONE SELF-RECTIFYING A.C. GENERATOR WITH TRANSISTOR REGULATOR

Progressive engineering at Delco-Remy has produced the most significant development in automotive electricity in two decades—the revolutionary new *golden milestone* self-rectifying a.c. generator and its companion all-new transistor regulator. This trend-setting new power team is designed specifically to meet the extra output requirements of *future* cars and trucks—beginning with 1959 models.

The compact new generator with its specially developed built-in silicon rectifiers can be installed quickly and easily with a minimum of change in standard d.c. electrical systems . . . offers a heavy charge at engine idle and up to *twice* the total output—with only a small increase in weight.

Delco-Remy's unique transistor regulator represents a bold new concept in voltage regulation—an electronic unit composed of durable long-lasting transistors and diodes *with no moving parts.* There are no mechanical components such as springs, hinges and contacts, so mounting position and vibration have no effect on operation, and the usual adverse effects of temperature and humidity are nullified. To the user, this means long-lasting settings, more accurate control of generator voltage, and elimination of periodic maintenance.

The Golden Milestone Power Team is an outstanding example of Delco-Remy engineering leadership in the automotive electrical field—of Progressive Engineering at work for you.

GM GENERAL MOTORS LEADS THE WAY—STARTING WITH Delco-Remy ELECTRICAL SYSTEMS

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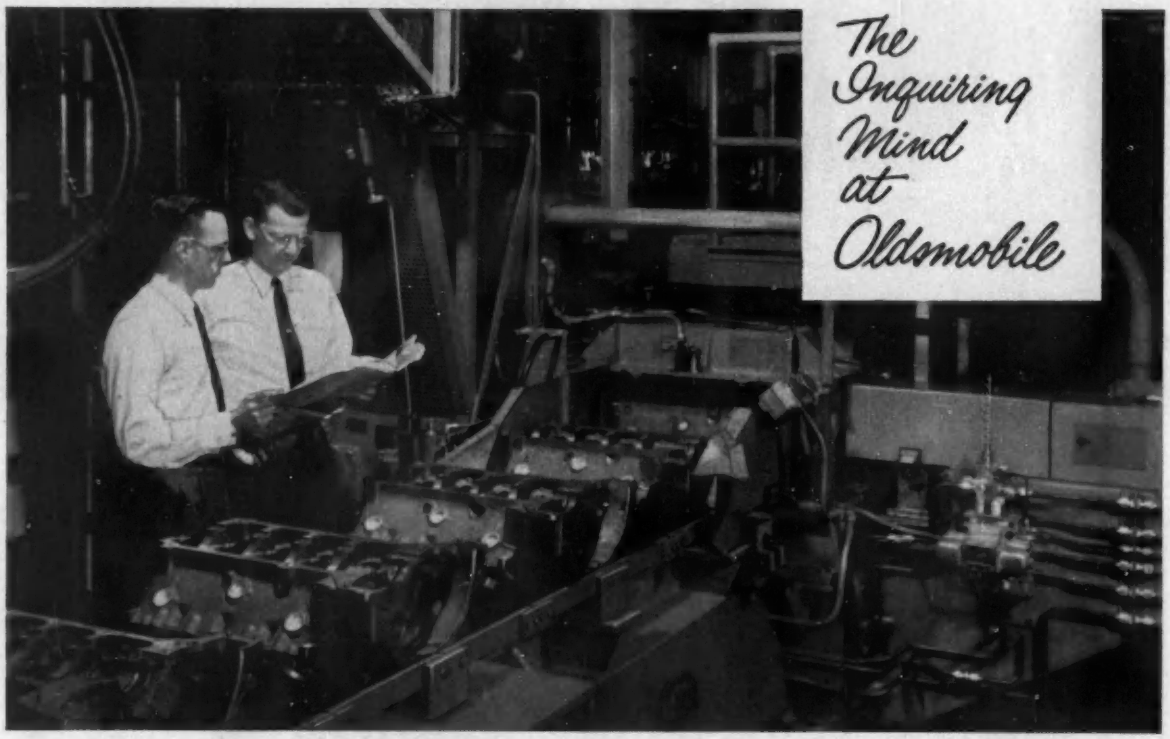

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no. 4 OF A SERIES

BEARINGS SO PERFECT YOU CAN "ROLL YOUR OWN"

Automatic camshaft assembly machine assures bearing surfaces so perfect that every Oldsmobile camshaft can be turned by hand.

Installing a camshaft in an engine is like threading a needle. In the hand assembly of this critical part, the cam lobes often score the bearing surfaces. This results in high friction that will 'freeze' a camshaft so that it can be very difficult to turn manually. Olds engineers, however, have developed the only automatic camshaft assembly machine in existence. It installs camshafts so precisely that every one can easily be rotated by hand . . . a guarantee of unmarred cam lobes, less friction and *longer bearing life!*

To go one step further in eliminating any possibility of damaged cam lobes and journals, all handling is done entirely by mechanical means. After grinding, polishing and washing, camshafts are fed by conveyor to the installation machine and mechanically loaded. As the camshaft is properly installed and located in the engine block, a uniform protective coating of oil is applied for proper lubrication before the engine is ever started. So precise is this machine that cam bearings are never touched by the lobes or journals passing through even though clearances are as low as 0.0015 inches.

Attention to small, frequently hidden details is the true mark of quality craftsmanship. At Oldsmobile, quality is not "What will pass?", but rather, "Is this the *best* way to build automobiles?". It is this search for better ways to make better automobiles that makes Oldsmobile distinctive—a car in a class by itself. Discover the difference for yourself. Your friendly Oldsmobile Quality Dealer has a test drive reserved especially for you.

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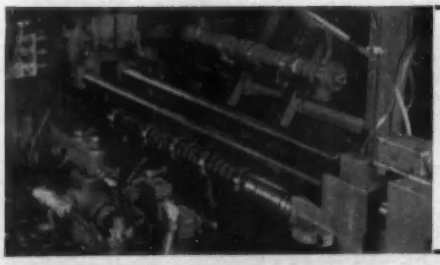
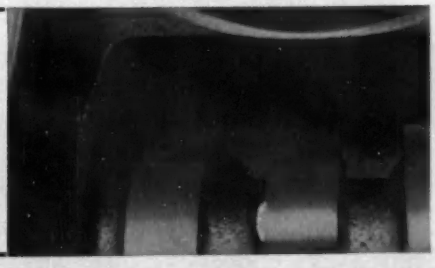


◀ Camshaft is rotated and lubricated as it automatically slides into engine block.

Scarred lobe on camshaft ▶ indicates scored bearing and may result in shorter camshaft and bearing life.



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Continued from page 6

elements: design and improvement change control; adaptability to change in production sequence planning; tool planning and design; machinery and equipment layout; four areas of production functional testing; philosophy applied to quality control.

Problems Peculiar to Missile Manufacture, R. E. SONNEKSON. Paper No. 44C. Presented Apr. 1958, 7 p. Problems involve several phases of overall process such as scheduling, reliability requirements, tooling, assembly techniques, and quality control procedures; field test requirements and necessity for "burn-in" testing; manufacturing test operations.

Cost Reduction in Missile Manufacturing, C. D. BLISS. Paper No. 44D. Presented Apr. 1958, 8 p. Cost of missiles can only be reduced by full understanding of factors that make them so costly; these include research and development, complexity of electronic and mechanical systems; frequent changes and improvements, and making of missile models; steps to be taken in outlining program for cost reduction and its organization.

TJ38 Commercial Jet Engine, L. GREEN, B. GORDON. Paper No. 45A. Presented Apr. 1958, 14 p. TJ38 Zephyr engine, developed by Wright Aeronautical and Bristol Aero Engines, embodies low temperature concept for improved operating efficiency, reliability, and lower noise levels; reasons for selecting concept and advantages of engine for use in commercial transport.

Maintenance and Development of Prop-Jet Engines, F. H. STEUBER. Paper No. 45B. Presented Apr. 1958, 17 p. Activities encompass design, test, prototype installation, tools, test equipment, training programs, publications, service, flight testing, and operational experience; relationship between maintainability and design demonstrated by considering design concept of Allison Model 501 prop-jet engine; differences in maintenance between turbine and reciprocating engines.

Primary Creep in Aircraft Design, B. B. MUVDI. Paper No. 46A. Presented Apr. 1958, 16 p. To meet requirements of future designs, performance of materials in primary stage of creep is investigated to provide information for material selection studies and stress redistribution analyses; test procedure and instrumentation employed; results on three materials (2024-T86 aluminum alloy, 17-7 PH stainless steel and 6A1-4V titanium alloy) indicate that, insofar as creep is concerned, titanium alloy is superior

continued

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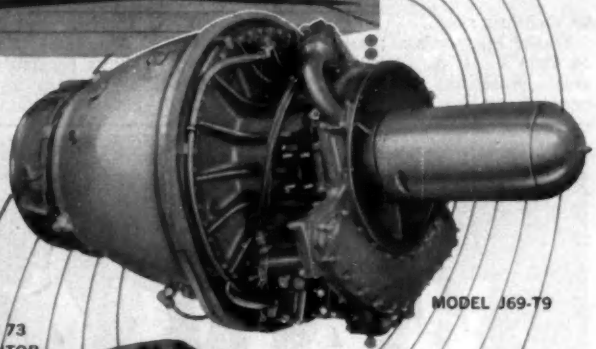

MODEL J69-T9

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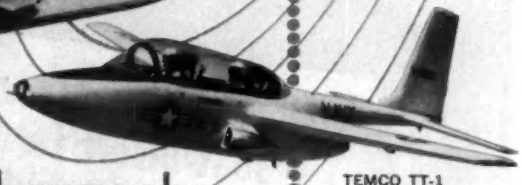

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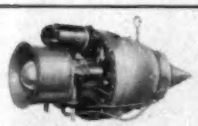
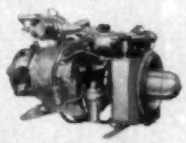
World's Largest Manufacturer of Small Gas Turbines

As the pioneer American builder of small gas turbines, Continental Aviation and Engineering Corporation occupies a unique position in this relatively new field of power. Not only is it the largest producer of engines of this type and size; it is also the most thoroughly qualified by experience, and the most completely equipped. Those having present or prospective need for gas turbine power—for applications on land, at sea, or in the air—are invited to lay their problems before C. A. E. engineers.



MODEL J69-T-19A



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Briefs of SAE PAPERS

Continued from page 131

to stainless steel.

Use of Materials at Temperatures up to 2000°F, H. A. PEARL. Paper No. 46B. Presented Apr. 1958, 18 p. Report summarizes highlights and philosophy applied to work sponsored by US Air Force at Bell Aircraft Corp.; interdependence of properties of materials and design; development of system for evaluating efficiency of metal for use in various structures; suitable thermal insulations; microwave dielectric properties of ceramics; use of ceramics for non-electrical purposes.

Corrosion and Oxidation Resistant Coatings for Metals for Operation at Temperatures from 1000°F to 2400°F, J. V. LONG. Paper No. 46C. Presented Apr. 1958, 14 p. Research work on coatings carried out at Solar Aircraft Co.; types and applications of SOLARAMIC ceramic coatings, with emphasis on jet engines; modifications include antigall dry lubricants coatings and reflective or emissive coatings; cermet coatings; study of flame spraying and powder flame spraying methods; process for aluminizing metal by using ceramic coating techniques.

Relation of Fuels to Aircraft Turbine Engines, E. A. DROEGEMUELLER, R. K. NELSON. Paper No. 47A. Presented Apr. 1958, 16 p. Approach taken by Pratt & Whitney Aircraft Corp. in determining minimum requirements for fuel used in turbine engines in commercial airline service; six performance categories, established in specifications PWA 522, are volatility, low temperature characteristics, compatibility with other materials; stability metering and burning characteristics; test methods and equipment; future projects.

Developments in Aircraft Turbine Lubricants, K. L. BERKEY. Paper No. 47B. Presented Apr. 1958, 9 p. Program at Wright Air Development Center resulted in development of Mil-L-7808 synthetic oils, organic diester materials with proper additives; main differences between mineral and synthetic oils are shown; development of screening tests, divided into laboratory and rig tests; present program covering target specification Mil-L-9236 involves study of 12 new oils of 400 F bulk oil temperature capabilities.

Turbine Engines for High Speed Missiles, R. E. NEITZEL, M. A. ZIPKIN. Paper No. 48A. Presented Apr. 1958, 15 p. Advantages; description of straight turbojet engine and combined turbojet-ramjet engine for flight speeds in vicinity of Mach 4.0; performance at cruise conditions and in acceleration region presented for sample set of assumptions; typical missile applications.

Design Problems of Very High Speed Flight, K. E. Van EVERY. Paper No. 880. Presented Feb. 1958, (Southern California Sec.) 20 p. To illustrate some specific problem areas, paper draws on research study Project D558-III, undertaken by Douglas Aircraft Co.; design configuration of manned aircraft capable of attaining very high altitudes and speeds from Mach numbers 2 to 38, to investigate aerodynamic, structural, operational and human factor problems involved in these flight regimes as step towards space travel.

Takeoff Progress Indicator, J. ANDRESEN, E. H. SCHROEDER. Paper No. 38C. Presented Apr. 1958, 6 p. Approach to problem of indicating to pilot of jet aircraft, early in takeoff, whether or not successful takeoff can be accomplished; indicator, devised by Kollsman Instrument Corp., uses two measured variables, indicated air speed, and time; schematic of essential elements; nomogram shows example of computation device which can be used.

Integrated Aircraft Air Conditioning System for Transport Aircraft, G. W. KNOWLES. Paper No. 861. Presented Nov. 1957, (Wichita Sec.) 19 p. System, developed for Fairchild F27 Friendship transport, incorporates op-

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erating regimes of vapor and air cycle systems which can be made to overlap, vapor cycle system acting as "topping" system during climb and being shut off at altitude at which air cycle system handles entire remaining cabin cooling load; cabin pressurization; conductive heat transfer coefficients.

Penalties of Existing Operational and Instrument Tolerances on Jet Transport Operations, J. T. DYMENT. Paper No. 50C. Presented Apr. 1958, 17 p. Information, obtained at IATA Technical Conference in Miami, Fla., 1957, represents typical penalties that can be expected with 300,000-lb jet transports; consideration of aircraft weight, instrument errors, effect of increased temperatures and takeoff; decreased pressure, effect of runway slope, etc.; fuel reserves and selection; air traffic control.

Factors Affecting Utilization of Air Transport, W. A. PAGE. Paper No. 50B. Presented Apr. 1958, 18 p. Utilization is measured by number of hours airplane flew each year and divided into revenue and nonrevenue flying; nine factors having bearing on utilization are: shape of traffic demand curve; competition factor; fleet size; type of operation; public acceptance; speed; design excellence; operational excellence and law of diminishing returns; use of computing aids in systems analysis approaches.

Applications of Operations Research and Computer Techniques to Airline Operations, L. ROSENFELD. Paper No. 50A. Presented Apr. 1958, 6 p. Areas for applying techniques and electronic data processing include market research, determination of flight schedules, flight assignments, maintenance scheduling, and long range planning; analysis of traffic problems; dependence and interlocking relationship of these areas raises possibility of encompassing company functions within integrated system.

Control Systems for Thrust Reversal, J. BURNETT, D. MOSES. Paper No. 49C. Presented Apr. 1958, 12 p. Two categories of controls advanced one for system restricted to initiation during landing roll, other for initiation during flight; actuation system under development discussed in relation to these requirements; its power transmission system is composed of variable displacement hydraulic pump designed as engine component; system believed to be adaptable to number of reverser systems, missions, and aircraft types.

Performance and Control of Variable Geometry Aircraft Inlets, J. H. MARAVEL, J. LYTTLE. Paper No. 49B. Presented Apr. 1958, 20 p. Principles of inlet design with emphasis on problems of matching inlets to turbojet engines; wind tunnel performance characteristics; specific design which incorporates both variable throat and capture area, illustrates capabilities of variable geometry design; consideration of closed loop and schedule controls.

Optimization Study Missile Auxiliary Power Systems, E. I. BROWN, R. W. McJONES. Paper No. 48D. Presented Apr. 1958, 15 p. Study considers various energy sources to apply to self-sufficient power unit of aircraft and missiles using ram jet and/or rocker power plants; possible power conversion units to provide specified form of power output; synthesis and comparison of complete systems in relation to overall requirements calling for 5–20 hp hydraulic supply and electrical energy for durations up to 1½ hr.

Missile Hydraulic Systems Requirements as Viewed by Missile Manufacturer, H. J. IDE. Paper No. 48C. Presented Apr. 1958, 7 p. Weapon systems of short flight operational times up to 10 min; hydraulic system, its use and its problems; essentially it consists of hydraulic power generating device, several servo actuators and connecting plumbing or manifolding; future requirements include fluid contamination control, incorporation of cartridge items to attain savings in space and weight, etc.

Problems Relating to Systems Checkout and Final Acceptance of Production Missiles, M. A. STEPHENS. Paper No. 48B. Presented Apr. 1958, 8 p. At Chance Vought Aircraft, shop continuity testing during manufacturing stages of Regulus missile production is

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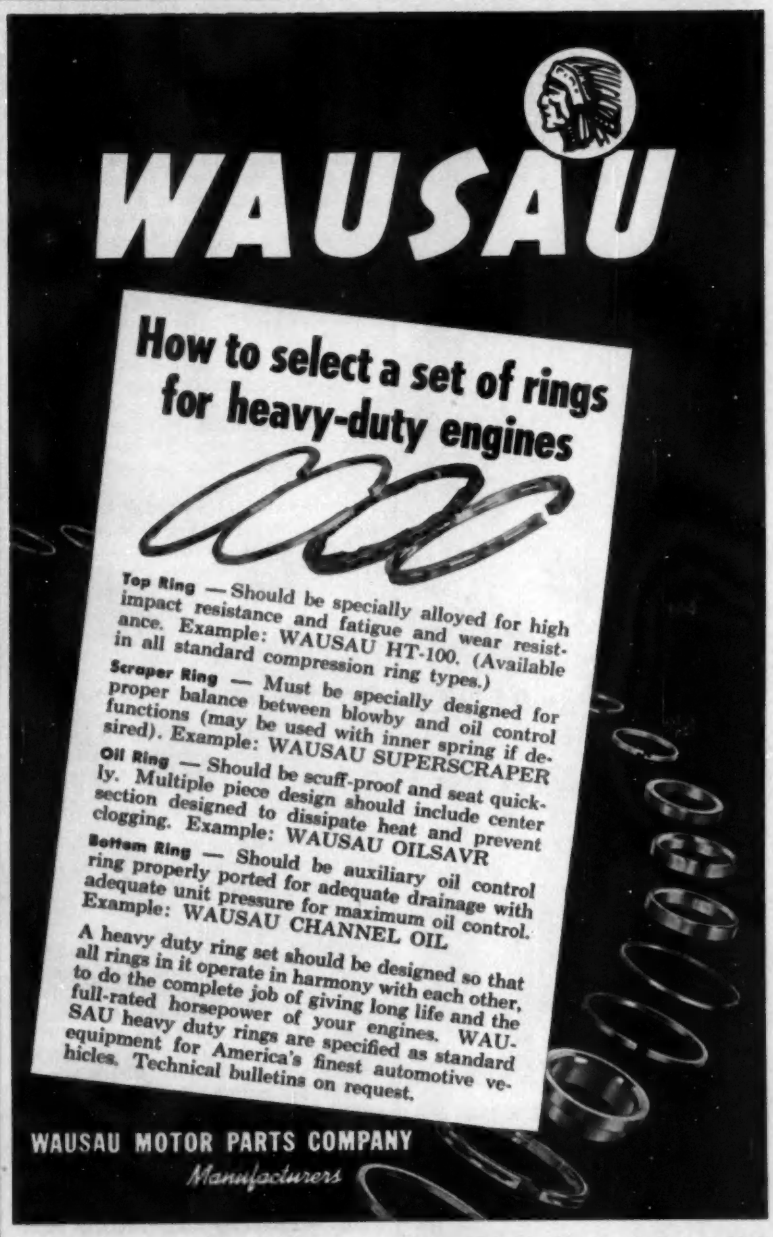
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Continued from page 133

concerned with quality control, and final acceptance with performance testing; each system is checked out on basis of being complete integrated system and also in conjunction with other dependent systems in its flight condition; acceptance requirements; determination of flight readiness.

COMPUTERS

Introduction to High Speed Electronic Digital Computers, C. W. SWIFT. Paper No. 33A. Presented Mar.–Apr. 1958, 12 p. Basic and historical concepts of computing; how scientific problem must be oriented to computer before solution can be obtained.

Computer Applications in Manufacturing, C. S. KNOX. Paper No. 33B. Presented Mar.–Apr. 1958, 8 p. Problems encountered in purchasing unformed steel at Caterpillar Tractor Co.; high speed electronic equipment used to solve problems rapidly and accurately; choosing best code size of steel for each individual piece part; other important fields for use of computers showing great promise for future research.

Application of Computer to Providing Processing Paperwork and Perpetual Status for Spare Parts Records, S. E. PARKS. Paper No. 45C. Presented Apr. 1958, 12 p. Computer used at Aircraft Gas Turbine Div. of General Electric is supplemented with four magnetic tape units, in addition to special system to enable selecting and printing from tape record; magnetic drum or memory unit has storing capacity of 20,000 characters in 2000 individually addressable locations; example of spare parts process tag.

FUELS & LUBRICANTS

How Fuels Can Help Improve Performance of Future High-Speed Compression-Ignition Engines, G. C. WILSON. Paper No. S64. Presented Feb. 1958, (Metropolitan Sec.) 16 p. Diesel fuel from standpoints of availability, properties, and combustion behavior in engines; to make available more fuels for military equipment, study was made of overall demands for petroleum fuels; as result, JP-4-type fuel was selected (essentially gas turbine fuel made up of high percentage of gasoline in blend with kerosine); possibility for adapting diesel engines to light fuels.

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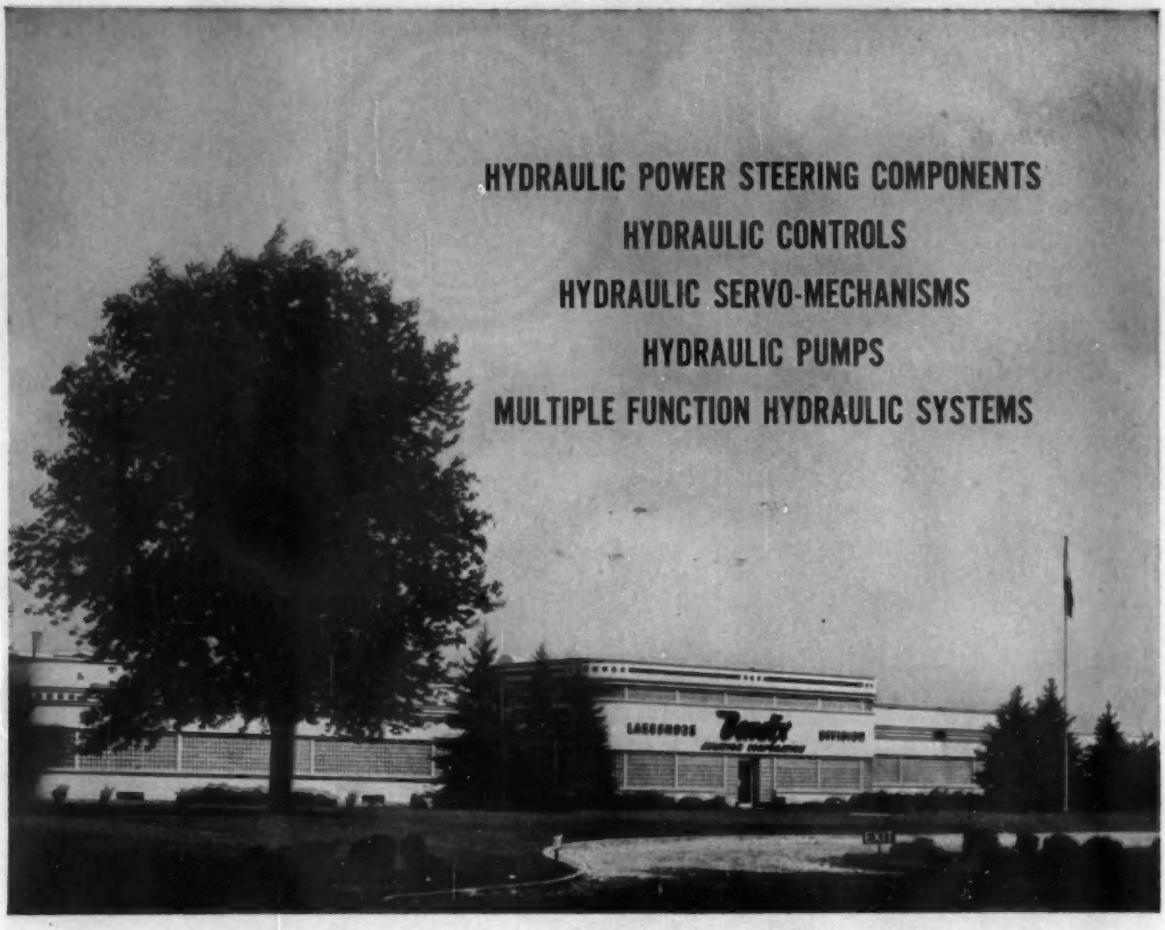

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Continued from page 134

tions, R. N. JANEWAY. Paper No. 15A. Presented Jan. 1958, 142 p. Studies carried out by special SAE Joint Subcommittee on Tractor-Trailer ride deals with basic factors considering criteria of ride performance and vehicle vibrating system; problems common to truck and tractor; problems peculiar to tractor-semitrailer combination; vehicle vibration on tires.

Automobile Head-on Collisions, Series II, D. M. SEVERY, J. H. MATHEWSON, A. W. SIEGEL. Paper No. 31A. Presented Mar. 1958, 52 p. Technical findings of experiments; collision performance of automobile structure; automobile impact analyses; post-collision observations with regard to car exterior; deceleration time patterns; collision performance by occupant with car interior; dynamic sequence injury production, with analysis of dummy's reaction to impact; lap belt performance.

Experiences in Six Cylinder Engine Development, F. R. KISHLINE. Paper No. 32A. Presented Mar. 1958, 6 p. Two 196-cu in. engines produced by American Motors are L-head used in 100-in. wheelbase Rambler American, and valve-in-head used in 108-in. wheelbase Rambler Six; engines offer low operating and maintenance cost, low manufacturing cost, low weight, compactness, and smooth operation; developments and experimental techniques by which engines have been adapted to take full advantages of recent improvements in fuel quality.

Engineering "W" Engine — Chevrolet's 348 Cubic Inch V-8, J. T. RAUSCH, H. H. KEHRL, D. H. McPHERSON. Paper No. 32C. Presented Mar. 1958, 10 p. Conception and design; preliminary studies and development program; durability test program; design details.

Chrysler Corporation's New V-8 Engine, R. S. RAREY, E. G. MOELLER. Paper No. 32B. Presented Mar. 1958, 19 p. Design requirements for new engine designed to meet market conditions requiring larger displacements; emphasis on minimum weight and production economy led to novel design features; particulars of component parts.

Ford Free Piston Engine Development, P. KLOTSCH. Paper No. 858. Presented Jan. 1958, (Texas Gulf Coast Sec.) 12 p. 519 Free Piston Engine Program concerned with determining thermodynamic relationships establishing proper engine geometry and with mechanical design; starting system; experimental power plant assembly employs 3-point rubber cushioned mount; fan, water pump, and piston cooling oil pump are driven from accessory gear; applicability to Typhoon tractor.

Disc Brake, S. E. SHERLOCK. Paper No. 866. Presented Jan. 1958, (Montreal Sec.) 9 p. Two main forms of caliper suitable for direct hydraulic operation are reaction type and opposed piston type; development stages of opposed caliper disk brakes suitable for passenger cars and commercial vehicles, adopted by Girling, Ltd.; current caliper, made in two halves and bolted together on center line; parking brake.

"Some Experiences with Throttle Body Deposits", K. B. VALENTINE. Paper No. 869. Presented Jan. 1958, (Southern California Sec.) 13 p. Increase in stalling difficulties directly traceable to throttle bore deposits; test program undertaken by Pontiac Div. to find cause; four items possess positive value for combating stalling; use of fuel additive; bypass idle air carburetor; electric pump and windshield wiper; drilling of ⅛-in. holes in primary throttle valves; gasoline and deposit frequency data.

Single Engine Versus Multiple Engine Power Plants for Off-Highway Haulage Equipment, K. M. LEECH. Paper No. 870. Presented Apr. 1958, (Central Illinois Sec.) 3 p. Evaluation of two methods of securing high power outputs is limited to 400-hp plant; consideration of each of factors affecting and affected by type of power plant; single engine power plant has two basic advantages: original cost of transmission combination, and possibility of either single or dual drive axles.

Some Basic Hydraulic Directional Control Valves and Circuits, M. M. COKER. Paper No. 871. Presented Apr. 1958, (Central Illinois Sec.) 20 p. Types of basic directional control valves available, their functions and characteristics, and types of circuits that may be used in actuating mechanism hydraulically; arrangements and modifications of components to produce special features in control system.

Excavator Economics in Earthmoving, E. O. MARTINSON. Paper No. 872. Presented Apr. 1958, (Central Illinois Sec.) 7 p. Factors applying to selection; methods for digging and loading include use of power cranes and shovels, self-loading scraper, front and tractor loader, bulldozer, grader and trenching machine; evaluation of efficiency factor; basic factors in operating cost analysis; greatest cost element can be fixed cost consisting of depreciation, interest and property tax.

How Performance Factors Affect Transmission Design, E. A. RICH-

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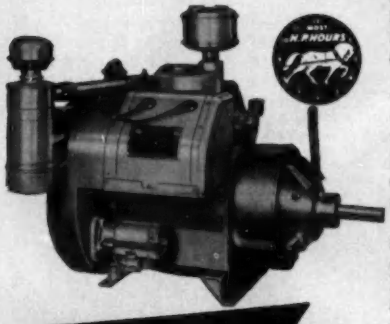

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Continued from page 137

ARDS. Paper No. S73. Presented Apr. 1958, (Central Illinois Sec.) 17 p. Two approaches to overall design problem considered, namely through mechanical gear box and torque converter; for purpose of discussion hypothetical diesel engine is of high speed turbocharged type as used in construction equipment; power source and drive components; means for obtaining desirable performance.

Contractors Approach to Design, D. A. ARMSTRONG. Paper No. S74. Presented Apr. 1958, (Central Illinois Sec.) 3 p. Servicing and preventive maintenance problems are arising from development and changes in design of earthmoving equipment; lag between production of unit and service and knowledge needed when unit is put into field; need for closer relationship between service departments and contractor; factors causing downtime; change of outside designs and parts, proposed.

"Truck Economics in Earthmoving", R. H. KRESS. Paper No. S75. Presented Apr. 1958, (Central Illinois Sec.) 5 p. Types of operation where truck seems to be most applicable; advantages and limitations of scraper, shovel and rear dump truck; reference to LeTourneau-Westinghouse 32-ton rear dump truck; short wheelbase of 129 in. permits turning circle of 43 ft which is close to similar capacity scraper; "Hydrair" suspension unit.

Air Springs from Jounce to Rebound, A. B. HIRTREITER. Paper No. S79. Presented Apr. 1958, (Southern California Sec.) 13 p. Three basic types are bellows of circular and elongated styles, rolling seal and piston, and friction seal and piston; characteristics and pertinent features; particular reference to combined air-steel spring using light leaf spring; list of recent air suspension papers published by SAE and ASME.

Brake Maintenance and Brake Development, W. TAUSS. Paper No. S82. Presented Feb. 1958, (Metropolitan Sec.) 8 p. Requirements of proper brake maintenance with reference to vehicles operated by fleets; development of materials, components, brakes, and devices to improve performance; major design problems include development of method to increase brake output, and methods or materials to eliminate heat and water fade; passenger car brakes; under development by Raybestos-Manhattan, Inc.

Compound Piston-and-Turbine Family of Engines — Progress Report and Future, A. L. LONDON. Paper No. S81.

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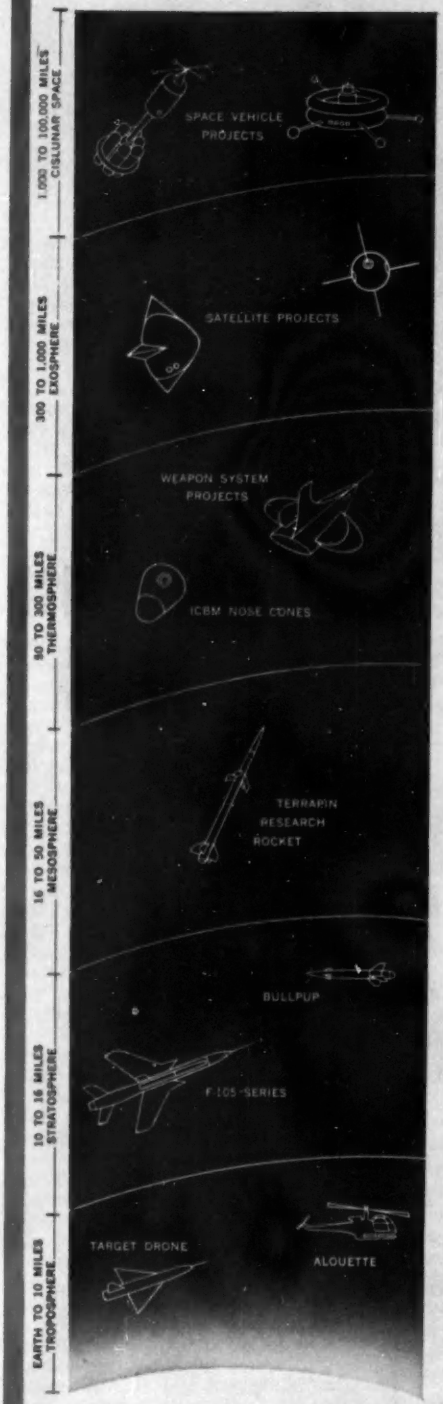
RESEARCH & DEVELOPMENT ENGINEERS AND SCIENTISTS



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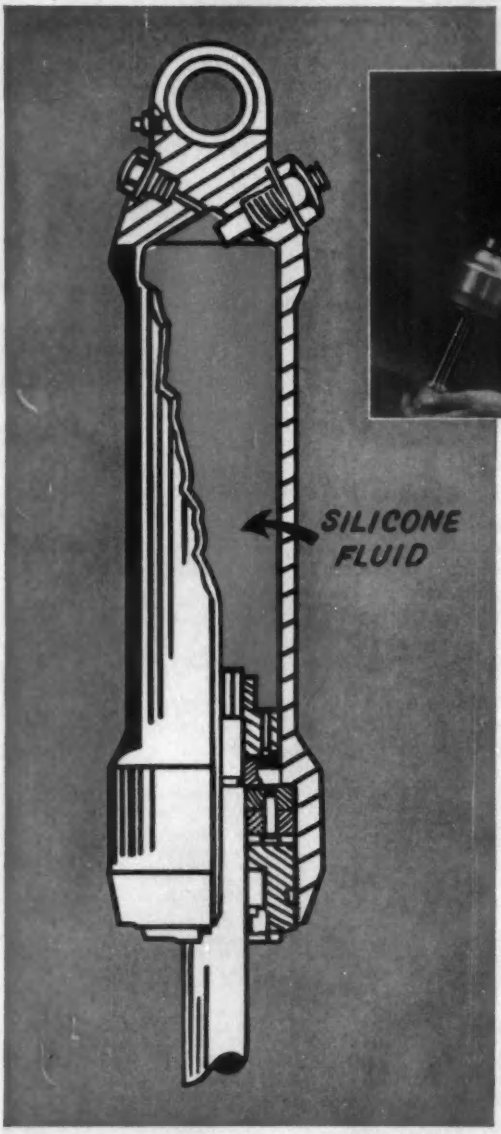

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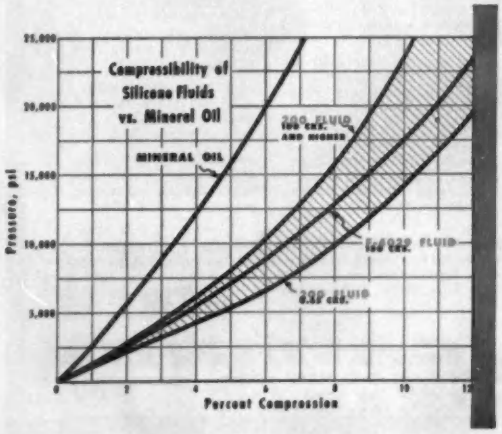

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Briefs of SAE PAPERS

Continued from page 138

Presented Feb. 1958, (Northern California Sec.) 5 p. Three types considered: turbo-compound as in Wright SI engines; Napier Nomad and Deltic diesel engines; crank piston and turbine engine with turbo power output as in Orion engine; free piston and turbine engine with turbo power output as in French SIGMA Model GS-34 1000 hp unit and automotive engines under development by Ford and General Motors; pertinence to locomotive or naval marine type diesel applications.

MATERIALS

New Developments in Steelmaking in Europe, D. L. McBRIDE. Paper No. 30C. Presented Mar. 1958, 9 p. Steel production in Western Europe and Russia increased by over 152 million tons since 1944; research done on low shaft blast furnace; electric smelting; much of European steelmaking capacity designed to produce acceptably low phosphorus steels from high phosphorus pig irons; applications of basic Bessemer process; development of oxygen steelmaking processes including L-D process, Kaldo process, and Oberhausen rotary furnace.

Use of Adhesives in Industry, F. J. WEHMER. Paper No. 34A. Presented Mar.–Apr. 1958, 7 p. Why and where adhesives are used; recommendations for their correct use; thermoplastic and thermosetting types.

Adhesives in Automotive Industry, C. J. RAWSON. Paper No. 34C. Presented Mar.–Apr. 1958, 7 p. Three major adhesive types discussed; thermosetting or vulcanizing adhesives used primarily for brake shoes and transmission bands; air drying or solvent evaporation type used for door and decklid weatherstrips, etc.; water dispersed adhesives; requirements of adhesives, their function and application.

Chromized Steel — New Low Cost, Heat, Wear or Corrosion Resistant Material, R. P. SEELIG. Paper No. 30B. Presented Mar. 1958, 8 p. Chromalloy process, or Chromallizing, is patented method of diffusing chromium and other elements into surface of metal; case histories illustrate applications and characteristics with regard to heat, wear, and corrosion resistance; suggested methods of utilizing technique for automotive applications.

Production of High Quality Steel Parts by Powder Metallurgy, R. TALMAGE. Paper No. 36B. Presented Mar.–Apr. 1958, 14 p. Comparison of mechanical properties of cold drawn 1020 steel with those of 0.7% C-5% Cu sintered steel; methods for production of high strength gears from sintered steel; factors which are important for obtaining good properties in gears such as proper selection of raw materials, good blending, accurate compacting, uniform sintering, etc.; low cost and other advantages of sintered steel gears.

Cold Working of Metals, D. J. DAVIS. Paper No. 865. Presented Feb. 1958, (Detroit Sec.) 16 p. Development, methods employed and progress made in cold extrusion and cold rolling of low and medium alloy steel parts; examples of automotive production applications; typical shaft forming sequence; spline rolling; advantages and future prospects.

Ultra High Strength, Heat Resisting Steel, J. C. HAMAKER, Jr. Paper No. 867. Presented Mar. 1958, (Southern New England Sec.) 12 p. Graphs, tables, and photographs selected from 5 yr of research data and field applications illustrate present knowledge on properties, fabricability, and application; of materials studied for use in aircraft and missile applications, 5% chromium steel called VascoJet 1000 appears to be best available for ultra high strength applications.

PRODUCTION

Operations Research. Paper No. 35A. Presented Mar.–Apr. 1958, 30 p.

continued

ROCKFORD

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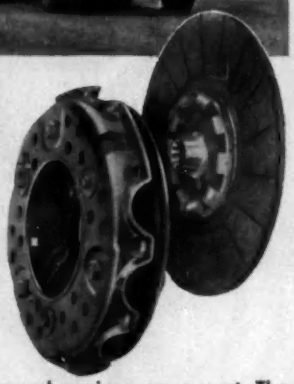
Are Adapted for Use with High-Speed Engines



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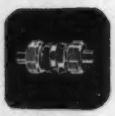
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Heavy Duty Over Center

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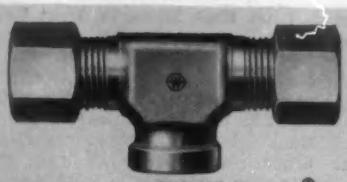
Speed Reducers

CLUTCHES



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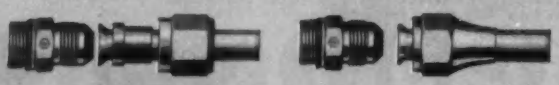

3-PIECE TYPE 2-PIECE TYPE

Briefs of SAE PAPERS

Continued from page 141

Part 1: History, Concepts, Techniques, Applications, by H. H. JACOBS, deals with technique as instrument for deciding how best to plan and operate production, distribution, and even military systems; two classes of mathematical models, namely, deterministic and probabilistic illustrated by examples involving operation of transportation system, two or more plants, and machine servicing problem.

Operations Research. Paper No. 35A.

Part 2: Identification, Formulation, Analysis and Interpretation, by G. COOPER, deals with formulation of OR problems its analysis and interpretation. **Part 3: Case Studies, by R. J. SCHREIBER,** concerned with two typical classes of problems involving production allocation and investment decisions.

Hot Precision Forgings and Extrusions, J. F. MURPHY. Paper No. 36C. Presented Mar.–Apr. 1958, 18 p. Three processes developed to provide high strength, high quality, low cost parts for aircraft and automotive industry, examined: precision gear forging, rotary forging process, and cross extrusion process; reference made to materials, properties, economics and future development; reference to German hot forging process.

Techniques and Material for Cold Extrusion, R. W. GARDNER. Paper No. 36A. Presented Mar.–Apr. 1958, 13 p. Evolution and progress; specific features which affect applications of cold extrusion of steel as process method; selection of product materials; lubrication; tooling techniques; flow of high strength material; control of lubricant flow.

UTILITY ENGINES

Two-Cycle Engine as Used on Chain Saws and Other Portable Equipment, W. B. BURKETT. Paper No. 862. Presented Jan. 1958, (Northwest Sec.) 17 p. Design and development program at McCulloch Motors, manufacturers of crankcase loop system scavenged 2-cycle engine, used in power saws for lumber industry; use of magnesium die castings; "all position" operation made possible by means of diaphragm carburetor; other applications.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

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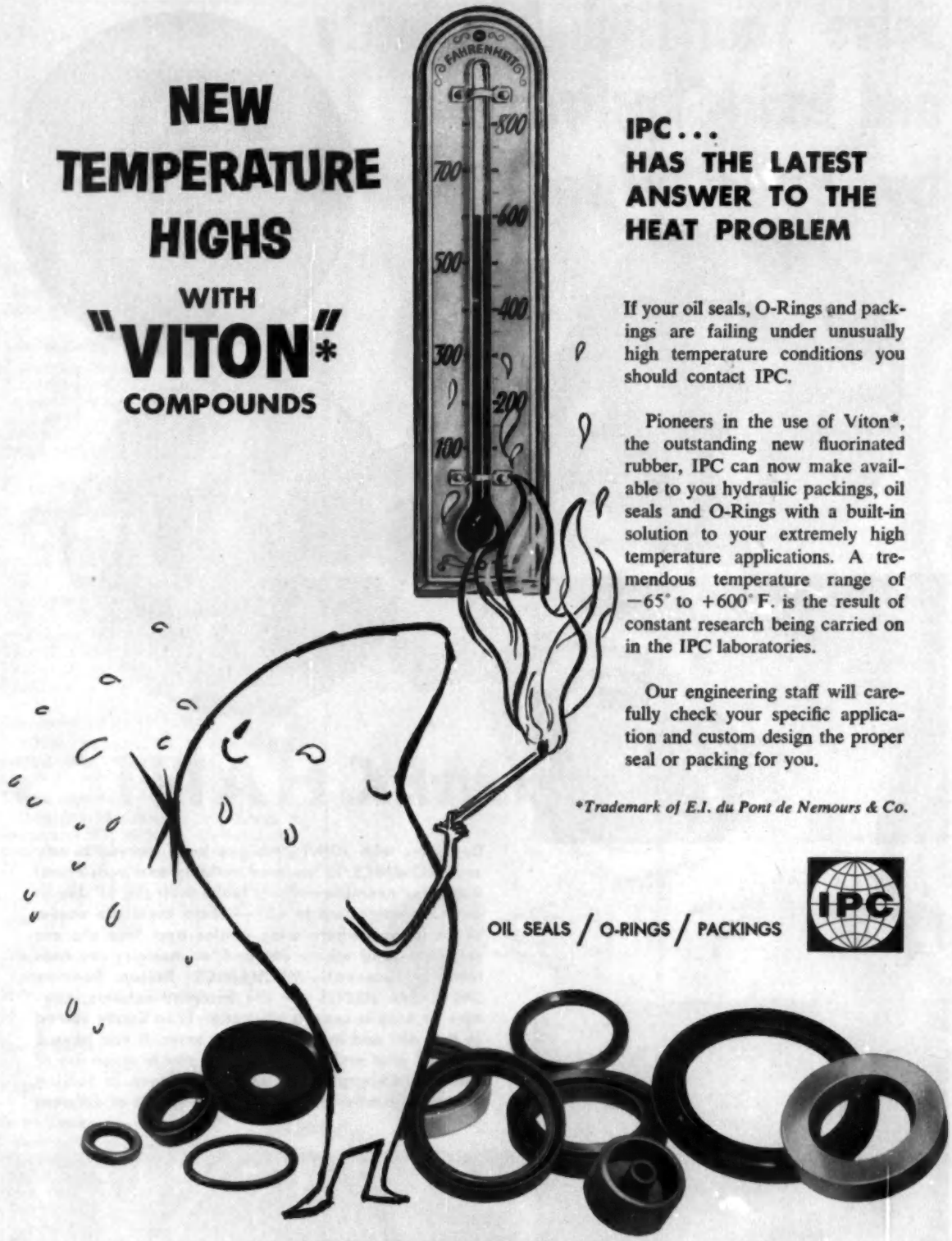

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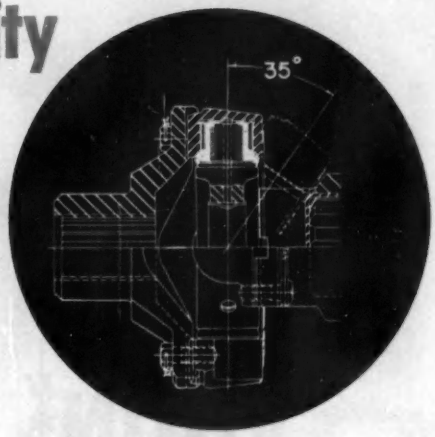

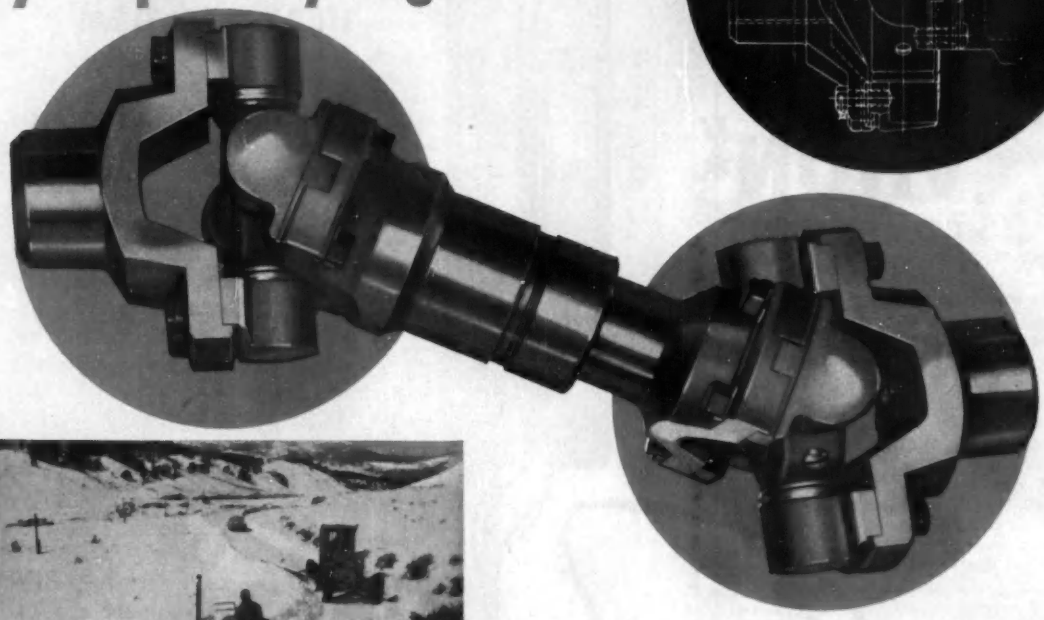

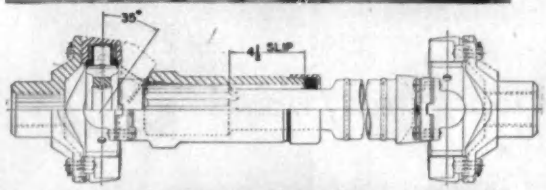

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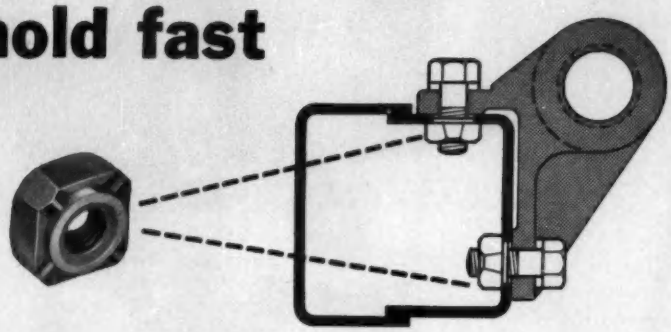
Continued on page 147

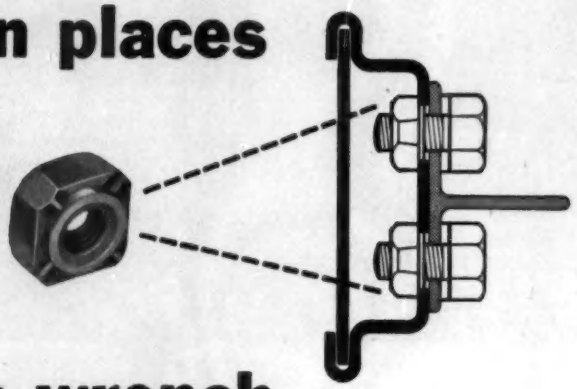
MIDLAND

WELDING NUTS

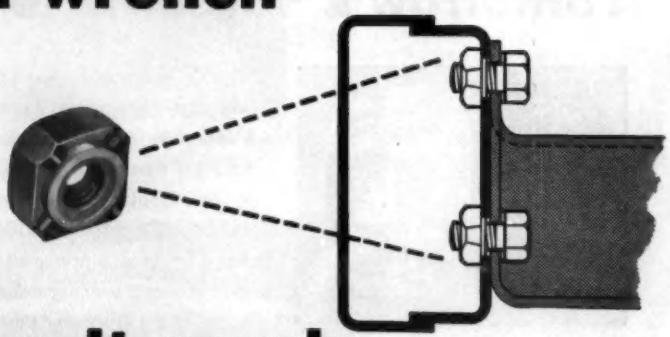
hold fast



in places



a wrench



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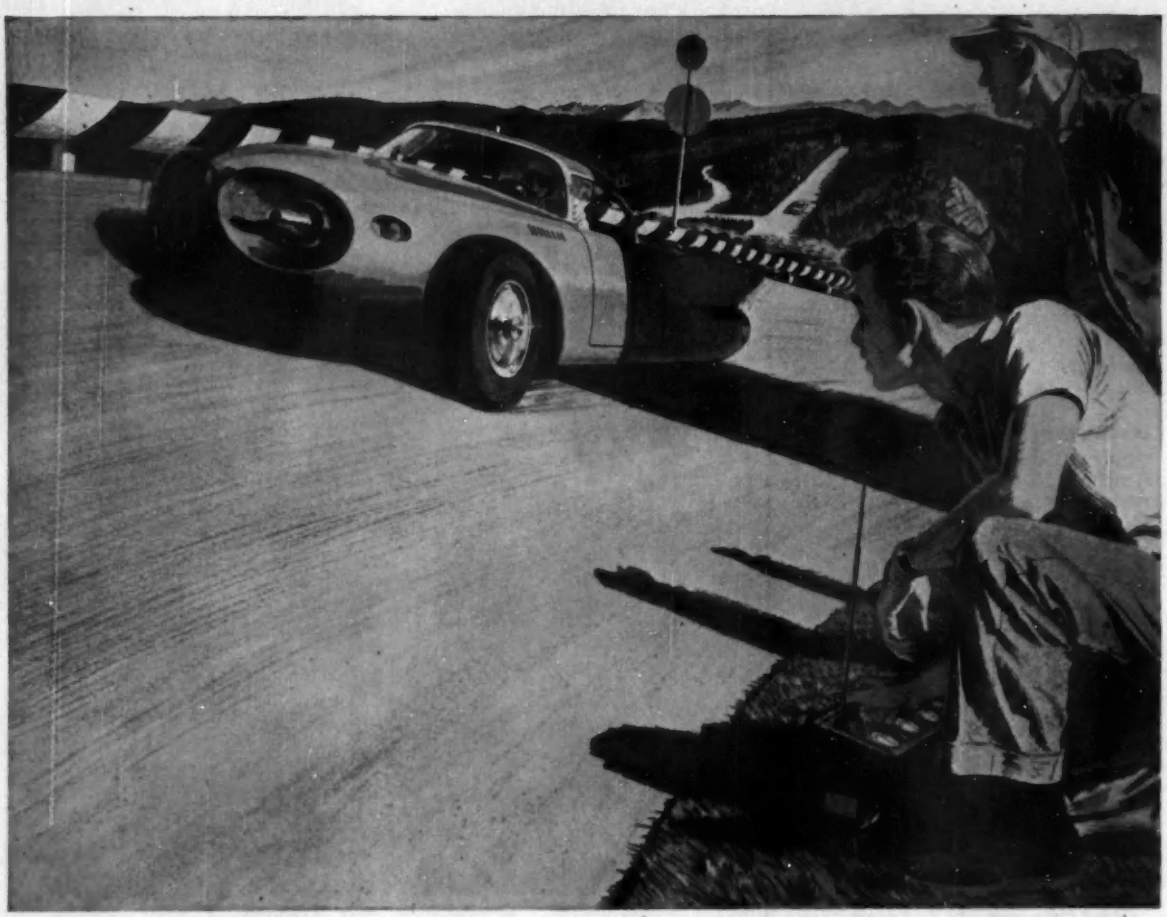

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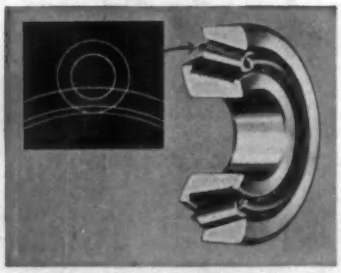

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Continued on page 148

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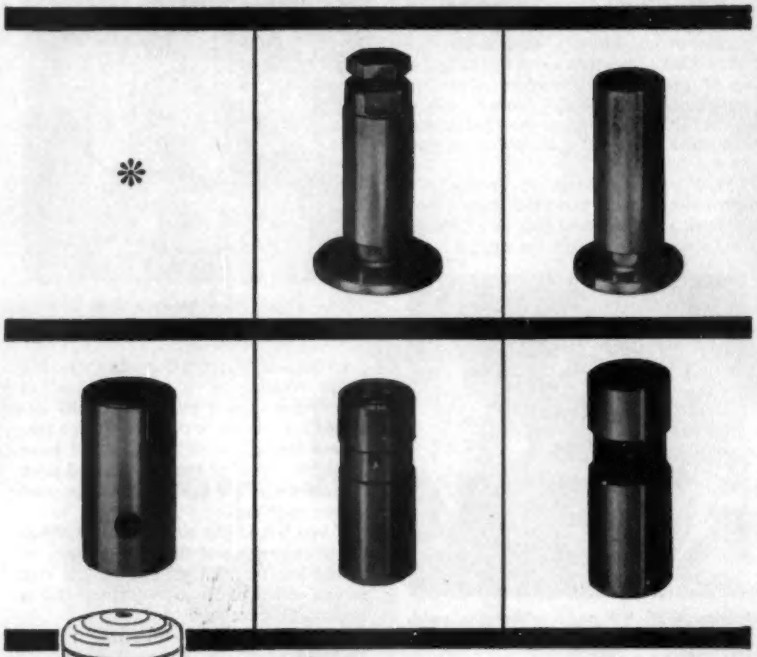
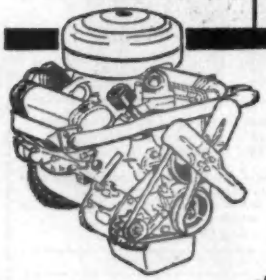
JOHNSON *tappets*





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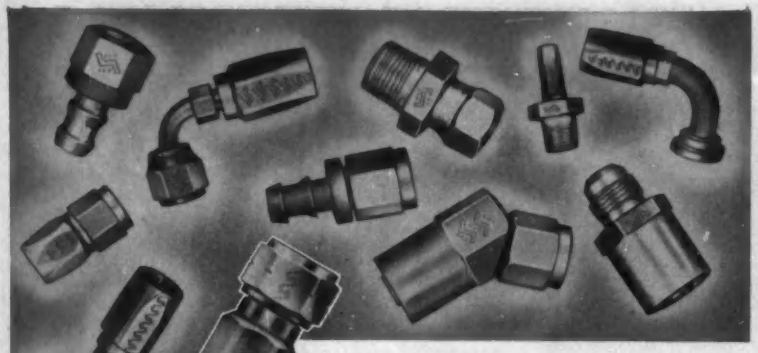

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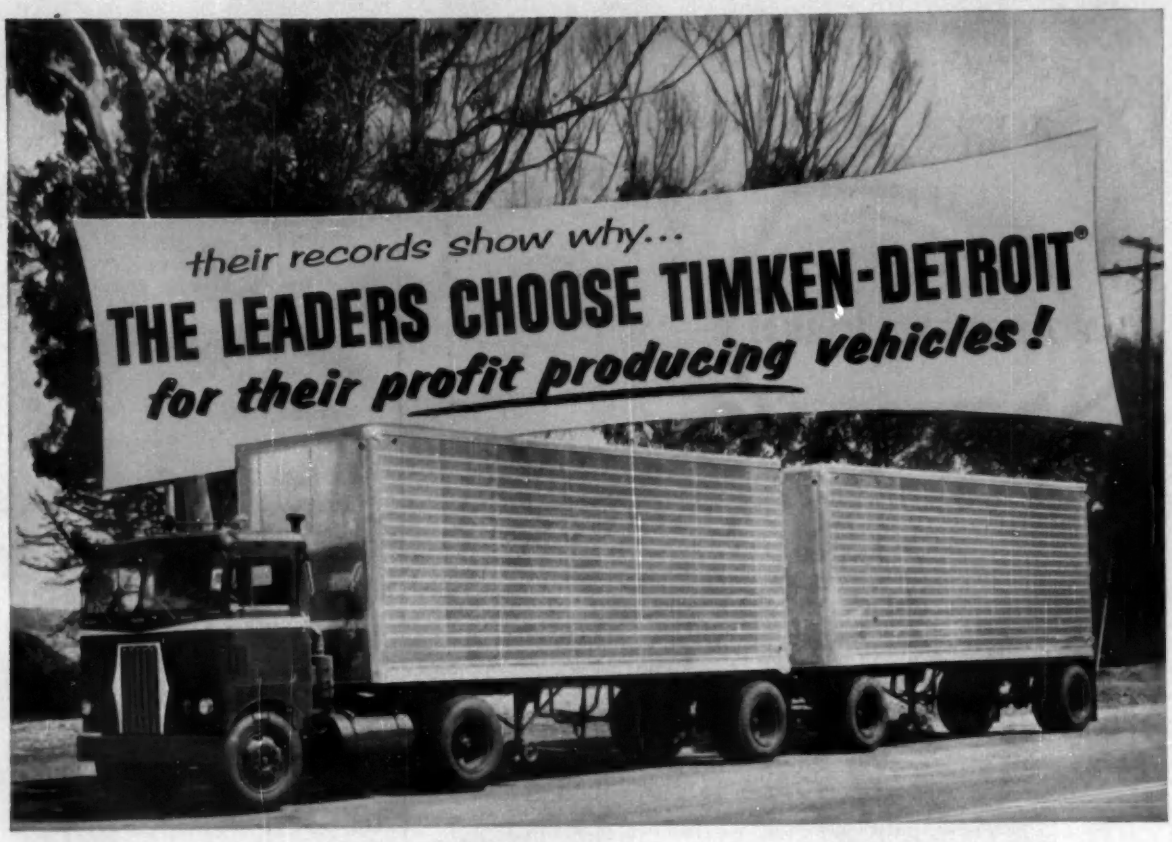
Continued on page 152



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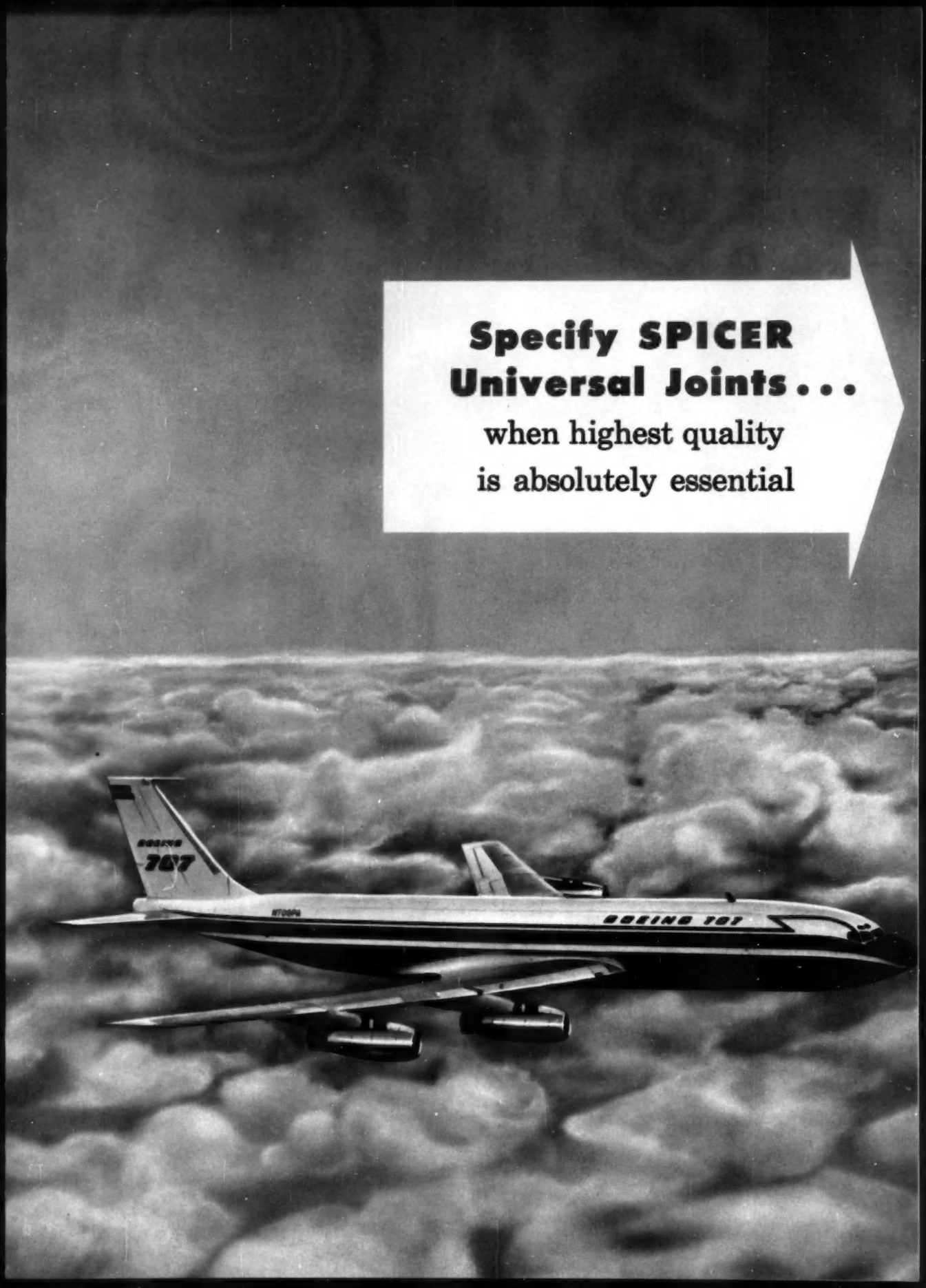
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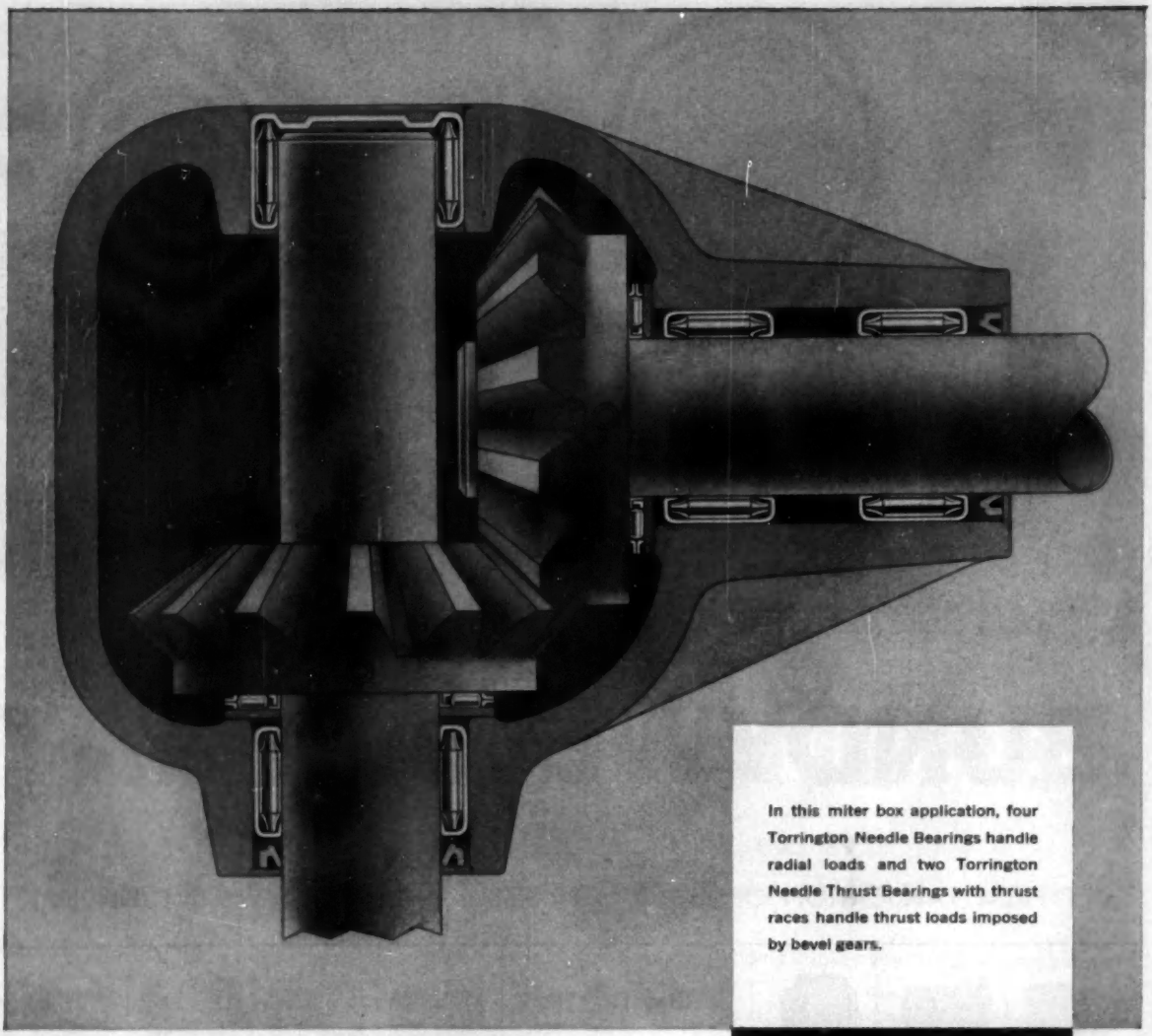
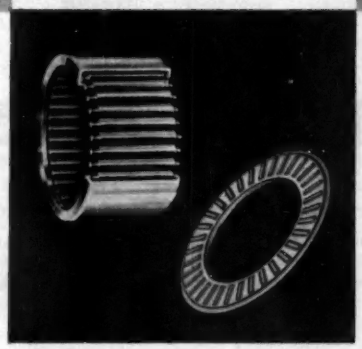


In this miter box application, four Torrington Needle Bearings handle radial loads and two Torrington Needle Thrust Bearings with thrust races handle thrust loads imposed by bevel gears.

Perfect Combination for Thrust and Radial Loads



Here's a space-saving, cost-saving way to handle high thrust and radial loads. Just team up Torrington Needle Bearings with Torrington Needle Thrust Bearings!

With their full complement of small diameter rollers, Needle Bearings handle higher radial loads than any other anti-friction bearing of comparable cross section. And Needle Thrust Bearings are only .0781" thick – as thin as an ordinary thrust washer. Together they make a perfect combination of compact, light, rugged anti-friction bearings.

Either type of bearing may be run on hardened and ground adjacent parts to meet minimum space requirements. Or they may be used with standard races available from Torrington. To make the most of this efficient combination, call on our engineering staff for application advice. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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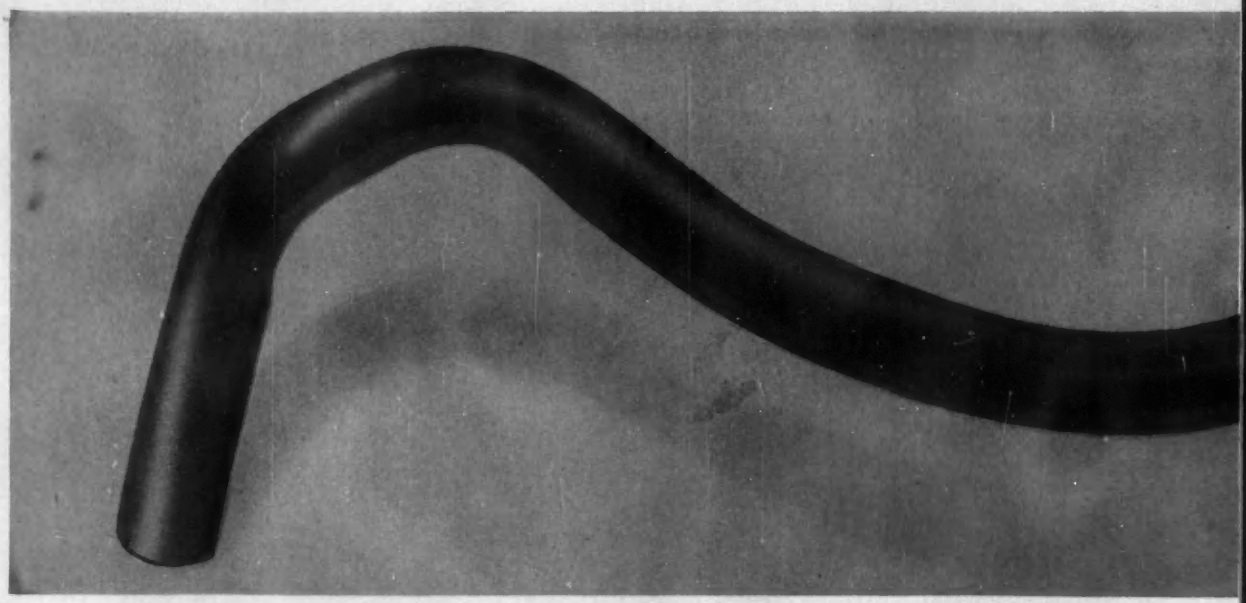
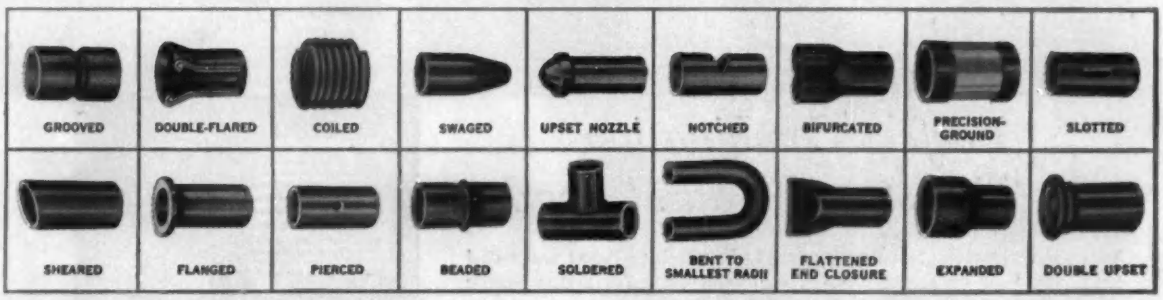


Multiple-bend discharge tube for refrigeration compressor is fabricated quickly, economically on Bundy-designed fixtures. Seven bends are put into a 7" length of ¼ x .028" Bundyweld in just one semi-automatic operation.

BUNDYWELD...BENT

TYPICAL FABRICATION OPERATIONS POSSIBLE WITH BUNDYWELD TUBING



Shown above are but a *few* of the fabrication operations possible with Bundyweld Steel Tubing. Many of these — and others not shown — were developed through solving a specific problem brought to us by a customer or prospect. At any stage in the development of your product, Bundy invites you to take advantage of this design service.

BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP

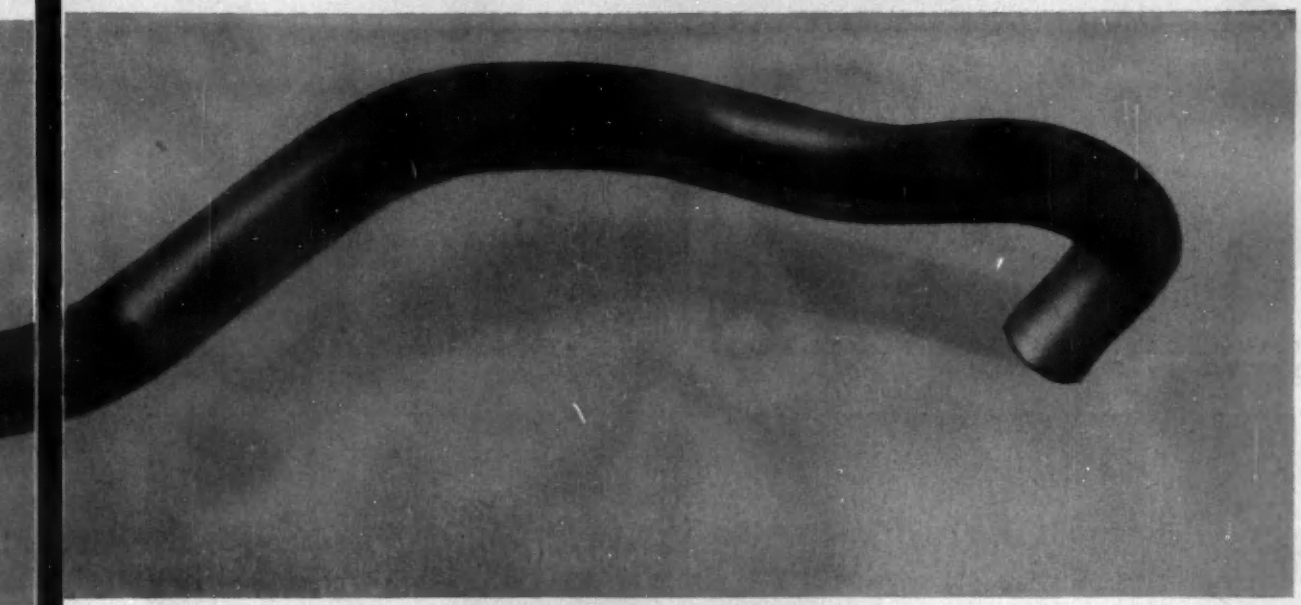
Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.



7 TIMES IN 7 INCHES

. . . and Bundy's fabrication experts mass-produced the part at low unit cost!

Seven bends in just seven inches—a tough fabrication operation, impossible with ordinary tubing! Yet Bundyweld® Tubing took the stresses . . . stayed *leakproof by test.*

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Bundy® engineers will design your tubing part, or work with your designers at any stage in the creation of a product. Many times they can point out money-saving shortcuts.

With Bundyweld, there's no such thing as an "impossible" bend. And Bundy can turn out tubing parts by the millions . . . package them with care, and deliver them right on schedule.

Check first with Bundy—where you get dependable Bundyweld Tubing plus unmatched design and fabrication services. Bring *your* tubing problems to Bundy. Call, write or wire us today!

BUNDY TUBING COMPANY, DETROIT 14, MICHIGAN

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There's no real substitute for

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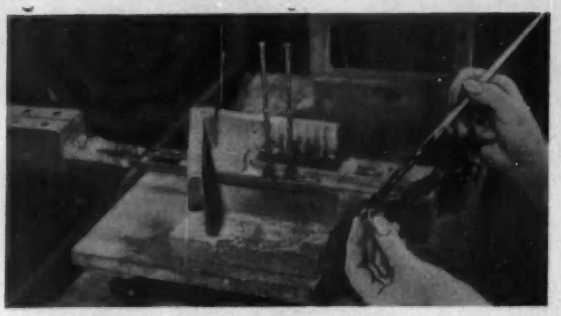
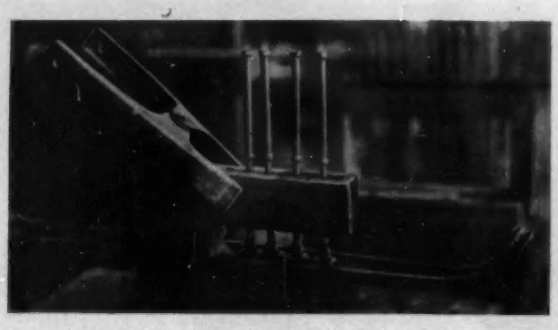
Bundy Tubing Distributors and Representatives: *Northeast:* Chas. H. Stamm, 10 N. Main St., West Hartford, Conn.; Austin-Hastings Co., Inc., 226 Binney Street, Cambridge 42, Mass. • ***Middle Atlantic:*** Atlantic Tube & Metals, Inc., 451 New Jersey State Highway #23, Wayne, N. J.; Rutan & Co., 1 Bala Ave., Bala-Cynwyd, Pa. • ***Midwest:*** Lapham-Hickey Steel Corp., 3333 W. 47th Place, Chicago 32, Ill.; Midco Supply Company, 1346 South 20th Street, Omaha, Neb.; Williams and Company, Inc., 901 Pennsylvania Ave., Pittsburgh 33, Pa. • ***South:*** Poirson-Deakins Co., 823-824 Chattanooga Bank Bldg., Chattanooga 2, Tenn. • ***Mountain:*** M. L. Fass, Inc., 1901-1927 Arapahoe Street, Denver 1, Colo. • ***Southwest:*** Vinson Steel & Aluminum Co., 4606 Singleton Blvd., Dallas, Texas • ***Northwest:*** Eagle Metals Co., 4755 First Avenue, South Seattle 4, Wash. • ***Far West:*** Pacific Metals Co., Ltd., 2187 S. Garfield, Los Angeles 22, Calif.; Pacific Metals Co., Ltd., 1900 Third Street, San Francisco 7, Calif.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.



Operator applying Special Handy Flux Type B-1 to components of de-icer tube before brazing.



Here, four de-icer assemblies in jig are being brazed by induction heat.

First step in brazing manifold. Operator applies Special Handy Flux Type B-1 to joint area prior to hand brazing. B-1 Flux is particularly effective in removing refractory oxides such as those formed in stainless steels and carbides.

Operator preheats joint area before hand feeding Handy & Harman silver alloy Braze 541.

Here, two different parts are being brazed. Operator in foreground hand feeds alloy on aircraft manifold joint while operator in background brazes nipple on hydraulic oil filter. Gas-air hand torches are used in both cases.

Here's how you can get uncompromising **JOINT STRENGTH** at **LOW-COST...** Handy & Harman **SILVER BRAZING**

The first requisite for virtually any aircraft part is unimpaired strength. Jerden Manufacturing Company, Indianapolis, makes a number of tubular aircraft parts and components and each of them must pass rigid tests before acceptance. Three of the components are a hydraulic aircraft filter, a manifold assembly and a de-icing tube. Tubes and fittings are 410 and 321 stainless steel, brazed with Handy & Harman silver alloy Braze 541 (formerly 4772).

Handy & Harman's Braze 541 is specifically formulated for brazing stainless steels. It has a high flow point (1575°F), and its excellent strength at elevated operating temperatures especially recommends it for many aircraft component applications. Braze 541 is a "tailor-made" brazing alloy, designed to do a specific joining job and do it particularly well. It is an example of Handy & Harman's ability to supply a specific alloy to fit a specific need, a service that remains constantly available to you.

You may find that your metal joining requirements are more or less special or you may not be fully aware of what you require. In any case, we invite you to consult us about what you are joining and *would like to join better*. We may be able to help you from many points of view: economy, joint strength, conductivity, ease of production and many others.

GET THE FACTS

Technical Bulletins T-1 and T-2 give the general characteristics of silver brazing alloys plus the compositions, melt and flow points of 36 separate alloys. Write for your copies.

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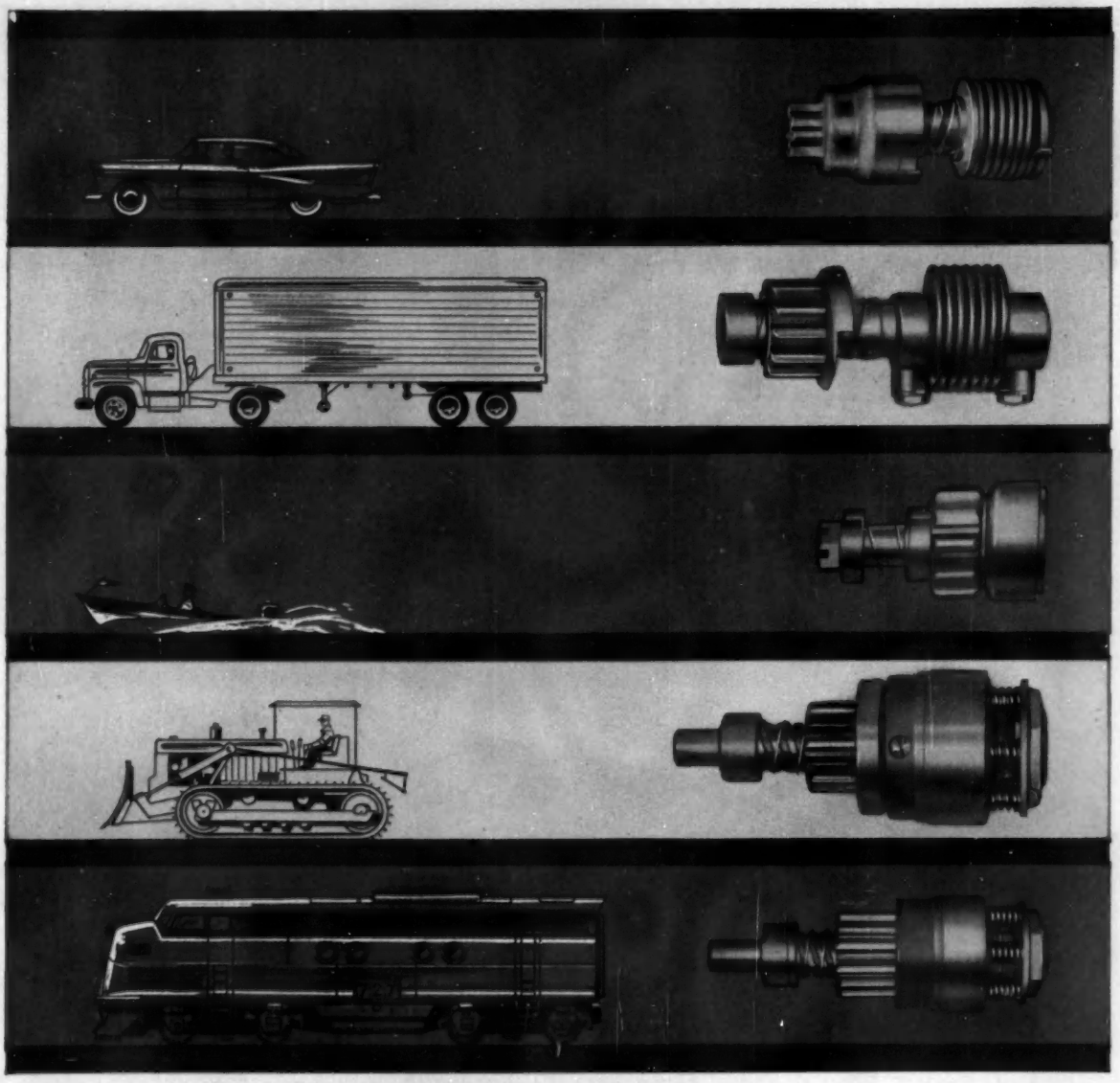

BIG OR SMALL . . . BENDIX DRIVES START THEM ALL

Throughout the world of transportation it's an accepted fact that *you start with Bendix!* And it's not surprising. Bendix* Starter Drives have been synonymous with dependability for fifty years in the automotive field. They've proved themselves just as reliable on submarines, aircraft, earth movers, outboard motors, helicopters. In fact, every type of internal-combustion engine ever built has used a Bendix Starter Drive. Hospitals use Bendix Drives to activate their stand-by equipment. Air raid sirens across the country are started with Bendix Drives. It's logical to believe that such universal acceptance indicates a standard of quality which no other manufacturer has been able to match. Need we say more?

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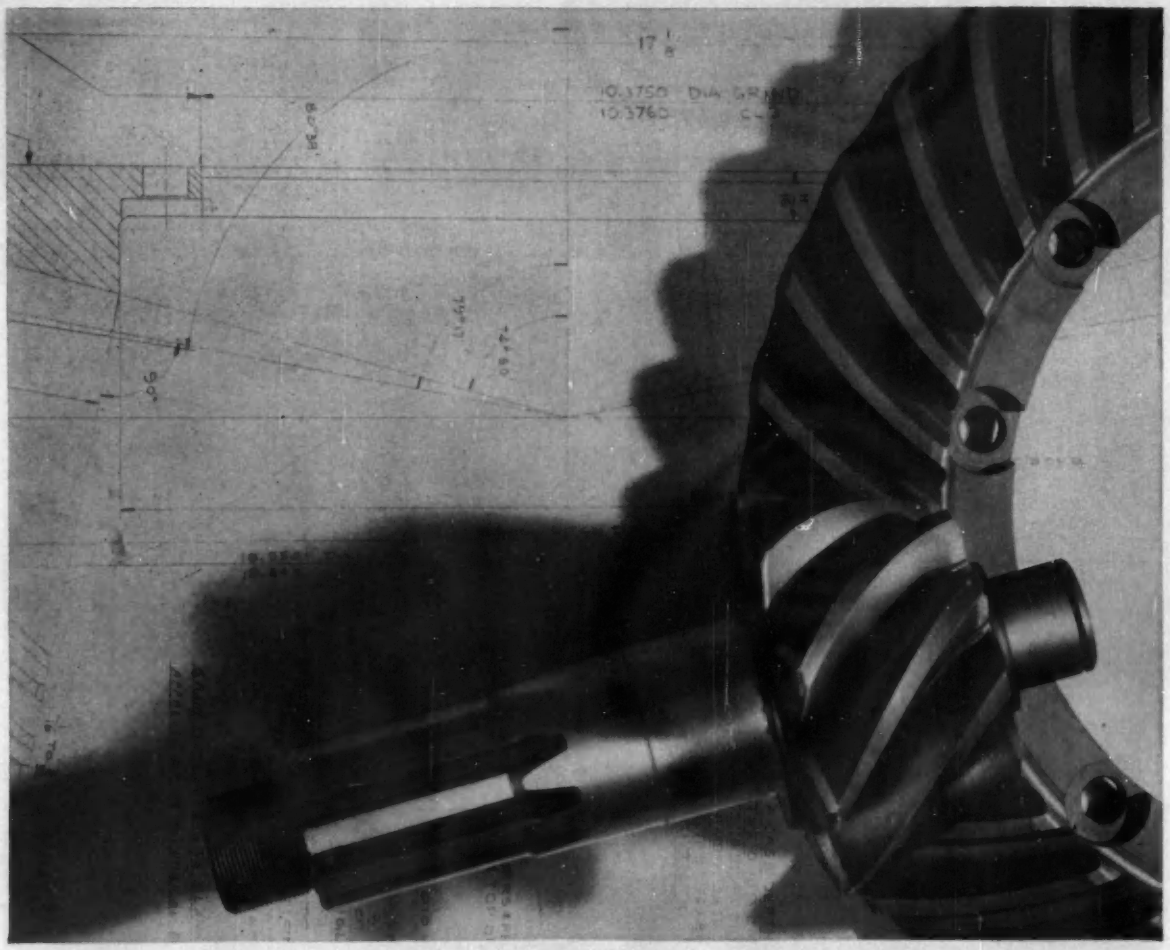


New big heavy-duty truck gear! Design based on 4820 Ni-Mo Steel

A new rear axle assembly for high output engines is now being produced by the White Motor Company.

It embodies all the advantages of a single reduction unit: simpler construction, lighter weight, shorter length.

Key element in this compact design is a big, 18½-inch ring gear — one of the largest ever made for a rear axle of this type.

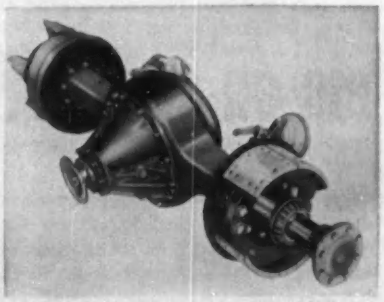
Carburized 4820 Ni-Mo Steel just right for gear

AISI Type 4820 (3.5% Nickel) gives this big gear its ability to cushion shock...take high tooth pressure... drive a gross combination weight of 180,000 pounds over mountainous terrain.

Type 4820 is one of many nickel-containing steels that offer a wide range of properties for improving the durability of heavy-duty axle components. These steels provide the strength, toughness, and other properties needed for a specific job.

For information to help you select the best alloy steel for your needs, get in touch with Inco's Development & Research Division.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N.Y.



Lightweight, high-torque capacity rear axle Model 134C — Built by the White Motor Company, Cleveland. Unit has a full range of ratios, permits top road speeds with low RPM engines.

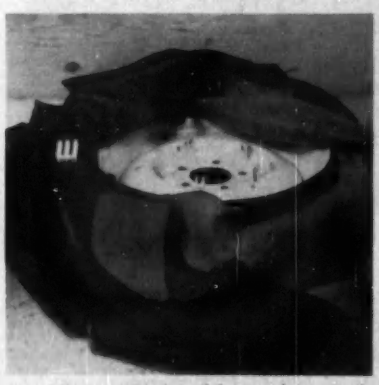
INCO NICKEL

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

NEW SUPER RAYON CORD TIRES OUTPERFORM ALL OTHERS IN RUPTURE RESISTANCE TESTS

This photo shows the violence of explosion caused by inflating a tire to the bursting point. Observers and camera technicians stay behind a protective concrete wall and operate remote controls.

Above is the 100 level Super Rayon Cord Tire that showed the least damage of all tires tested, and resisted the greatest force (302 lbs. per sq. in.)



Here is the tire which showed the most damage in the tests . . . a 100 level thermoplastic cord tire.

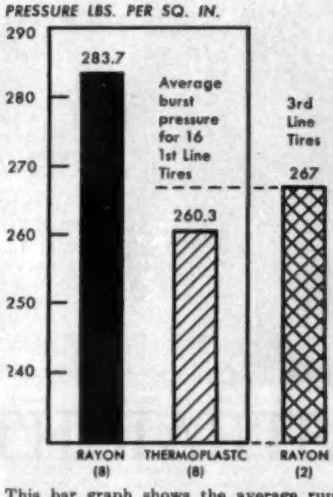
Tires were literally exploded in these comparative rupture resistance tests, which were carried out to determine the validity of current claims for the superior strength of tires made with the thermoplastic cord. The results did not support these claims, but rather proved the rupture resistance of Super Rayon Cord to be greater than that of the other cord by a wide margin (see chart).

All tests were performed with new tires of 100 level Rayon and thermoplastic cord of 100 level or above, from major tire companies and one of the largest chain stores. To determine rupture resistance each tire, under carefully controlled identical conditions, was inflated with compressed air at a given rate until it burst. Highly accurate instruments gauged and recorded pressure within the tire during inflation, and at the precise second of rupture.

The manner in which the tires burst furnished valuable clues to the strength and stretch characteristics of the various individual components. As the charts indicate, the final tabulations clearly show a superiority for tires built with Super Rayon Cord in the grades and brands involved in this test series.

TIRE BRAND 1st LINE	TIRE CORD	BURST PRESSURE
Chain Store	R	272 psi
Chain Store	R	276 psi
Chain Store	N	241 psi
Chain Store	N	248 psi
Mfr. A	R	270 psi
Mfr. A	R	302 psi
Mfr. A	N	276 psi
Mfr. A	N	270 psi
Mfr. C	R	284 psi
Mfr. C	R	276 psi
Mfr. C	N	278 psi
Mfr. C	N	272 psi
Mfr. D	R	300 psi
Mfr. D	R	290 psi
Mfr. D	N	258 psi
Mfr. D	N	240 psi
3rd LINE TIRES	(2) TIRE CORD	BURST PRESSURE
Mfr. A	R	267 psi (average)

All tires were new 6.70 x 15, mounted on standard Chevrolet rims.



This bar graph shows the average rupture resistance of all 1st line and 3rd line Rayon tires and 1st line thermoplastic tires used in the tests. Not only was the average rupture resistance of Rayon tires greater, but in every individual brand comparison Rayon tires were superior. You'll also note that even the 3rd line Rayon tires proved to be stronger than the average of the 1st line thermoplastic tires.

Write today for Motor Vehicle Research Report No. 5, covering rupture resistance in tires . . . it is free.

AVISCO SUPER RAYON TIRE CORD

AMERICAN VISCOSE CORPORATION • 350 Fifth Avenue, New York 1, N. Y.

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

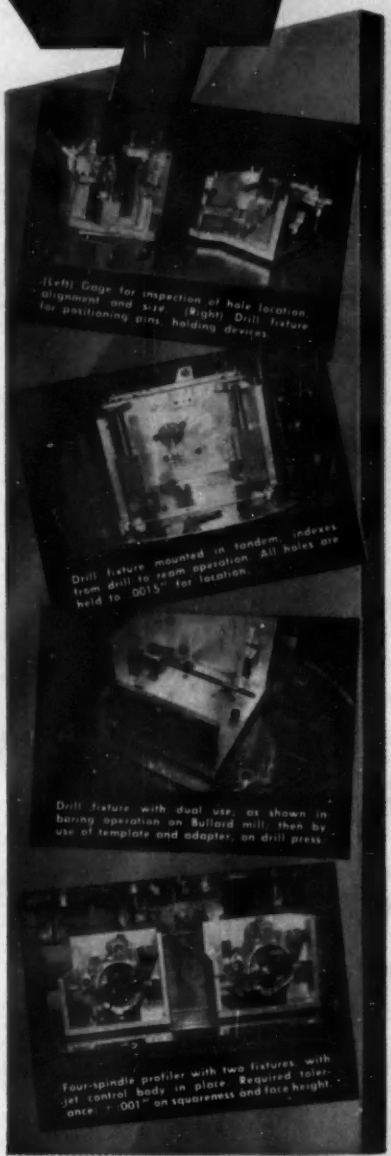
I'm sure you've heard about Douglas projects like Thor, Nike-Ajax, Nike-Hercules, Nike-Zeus, Honest John, Genie and Sparrow. While these are among the most important defense programs in our nation today, future planning is moving into even more stimulating areas.

Working as we are on the problems of space flight and at the very borderline of the unknown, engineering excellence in all fields is essential. For you engineers who can help us move forward, opportunities are almost as limitless as space itself.

If you thrive on tough problems – and there are many – we'd like to discuss a future at Douglas with you.

Please write to Mr. C. C. LaVene
Douglas Aircraft Company, Box 620-O
Santa Monica, California

4 EXAMPLES of many thousands SHOWING Why PIONEER 921-T TOOLING PLATE is the choice of TOOL ENGINEERS



(Left) Gage for inspection of hole location, alignment and size. (Right) Drill fixture for positioning pins, holding devices.

Drill fixture mounted in tandem indexes from drill to ream operation. All holes are held to .0015" for location.

Drill fixture with dual use, as shown in boring operation on Bullard mill; then by use of template and adapter, on drill press.

Four-spindle profiler with two fixtures with jet control body in place. Required tolerance: ± .001" on squareness and face height.

Pioneer 921-T Cast Aluminum Tooling Plate can be adapted to any precision tooling job without preliminary milling. Every Pioneer 921-T plate, ¾" or more in thickness, is held within a flatness tolerance of .010" in all directions. It is extremely stable, weighs 60-70% less than tool steel and possesses high tensile strength. The special aluminum-titanium alloy composition of Pioneer 921-T and method of casting insures uniformity, and guarantees freedom from porosity, distortion and casting defects. Being easily sawed, tapped, milled or welded, Pioneer 921-T is a universal tooling metal, saving material, time and man hours to reduce overall tooling costs.

At the left are shown a series of precision fixtures in which Pioneer 921-T was used in order to meet close tolerance requirements in the manufacture of a jet fuel component. Mail the coupon and receive free, all issues of TOOL TALK, presenting new and unusual applications of Pioneer 921-T.

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There are also good reasons why Edsel uses RCI FOUNDREZ resins. For one thing, continuity and quality control in resin manufacture are assured because RCI is a basic producer of both phenol and formaldehyde. In addition, 35 years of wide experience in synthetic resin manufacture is concentrated in RCI's Detroit plant, where these FOUNDREZ materials are produced.

If you have a foundry job where shell molding may offer advantages, write the RCI Foundry Division for full information on FOUNDREZ resins.

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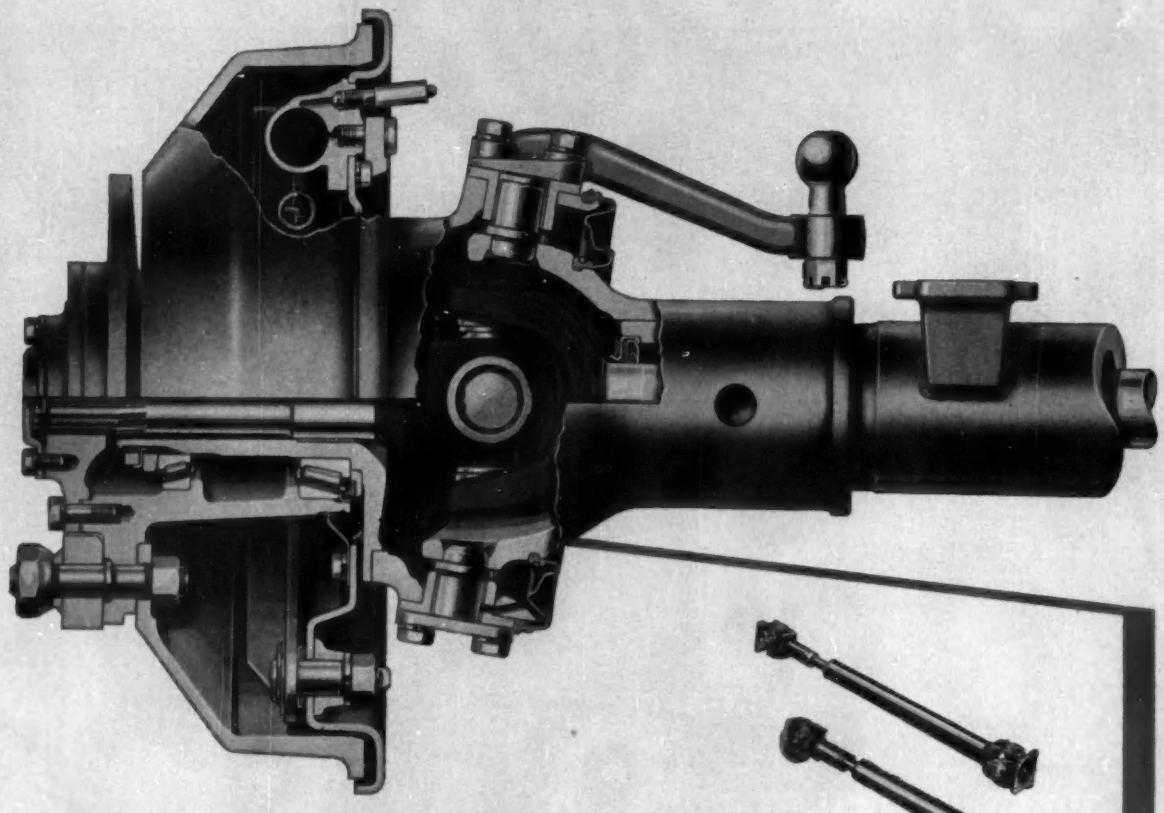

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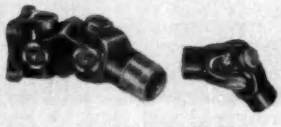

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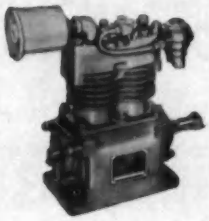
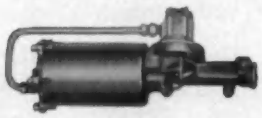


Model 7.4 Air Compressor



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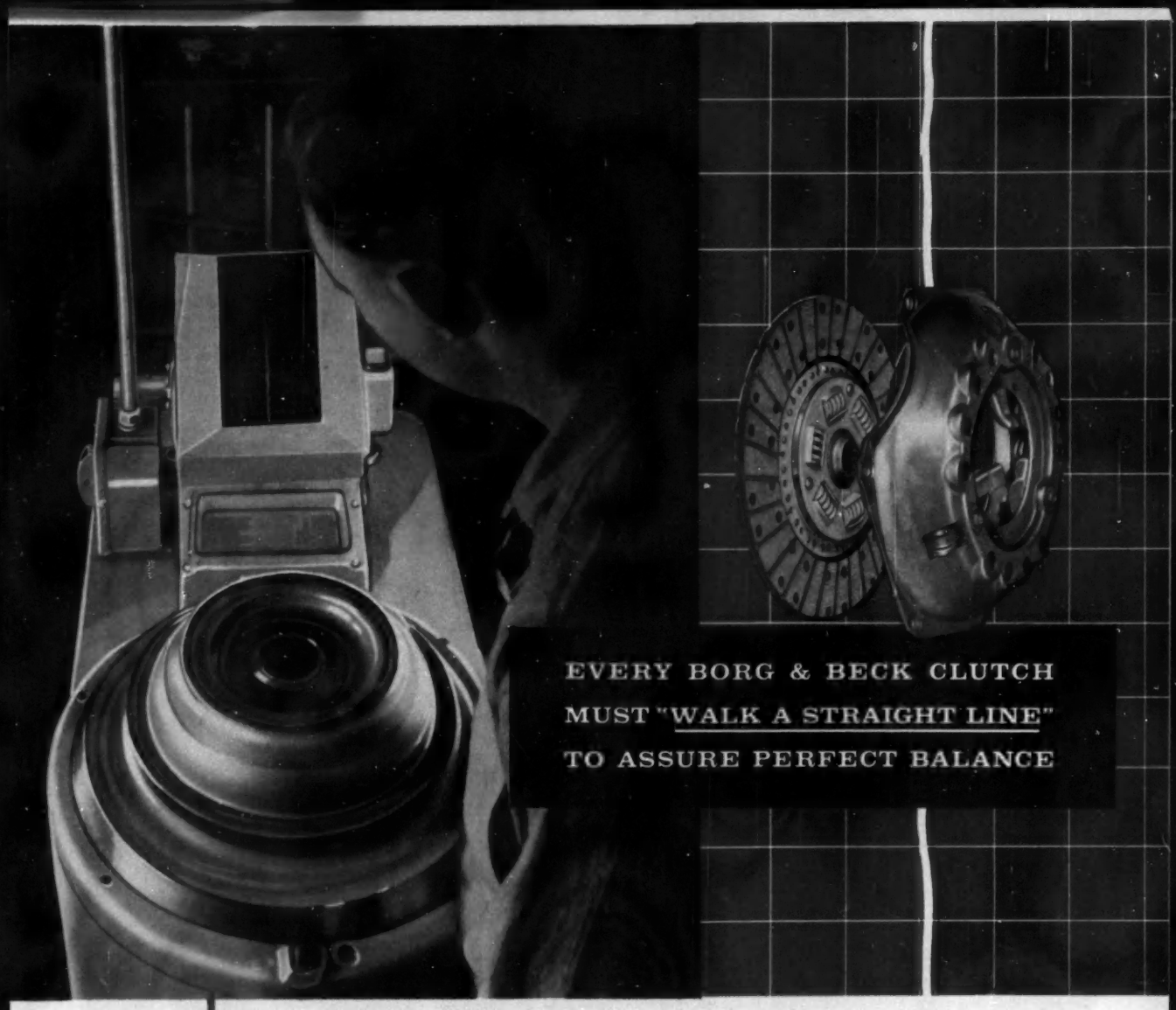

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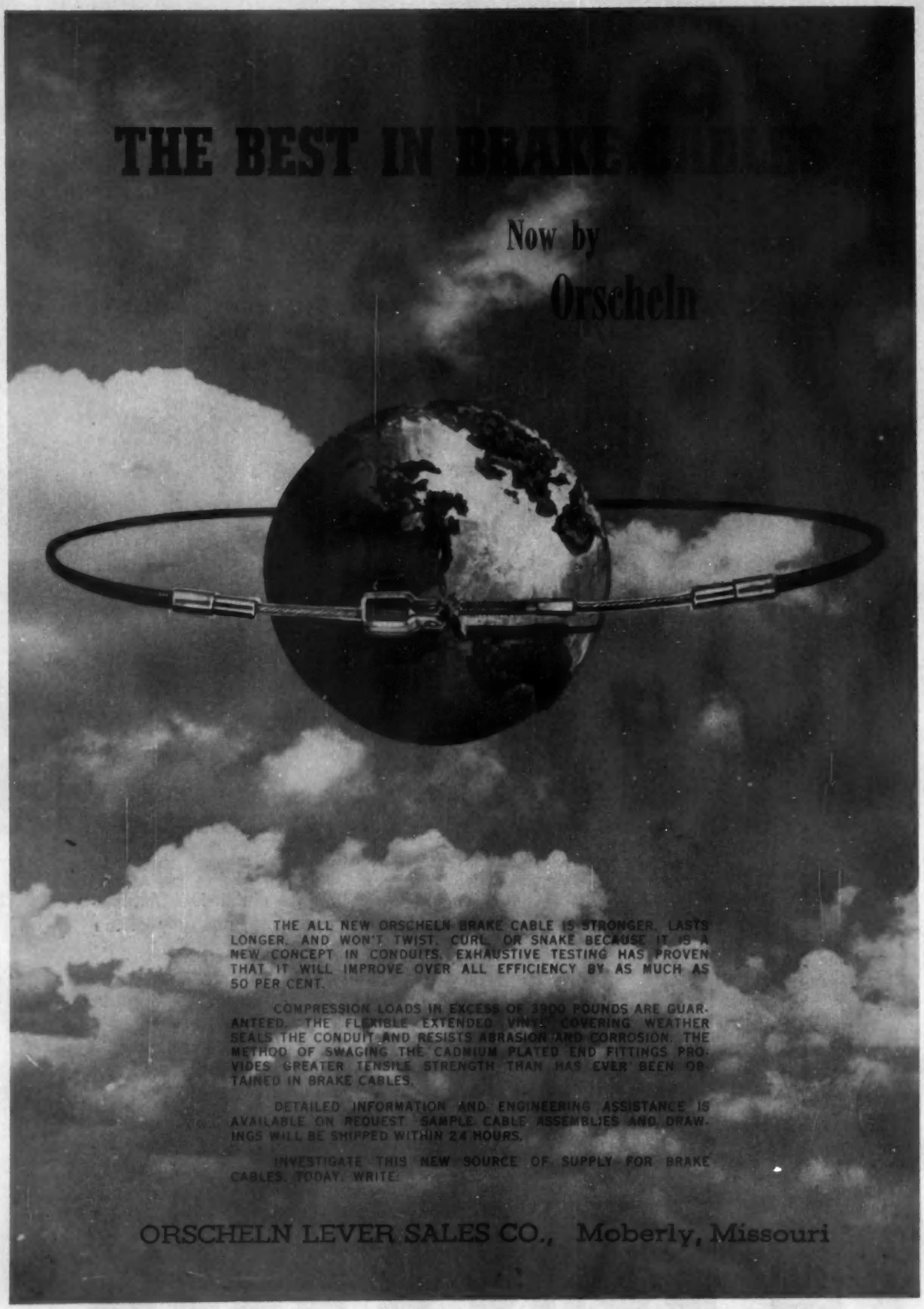
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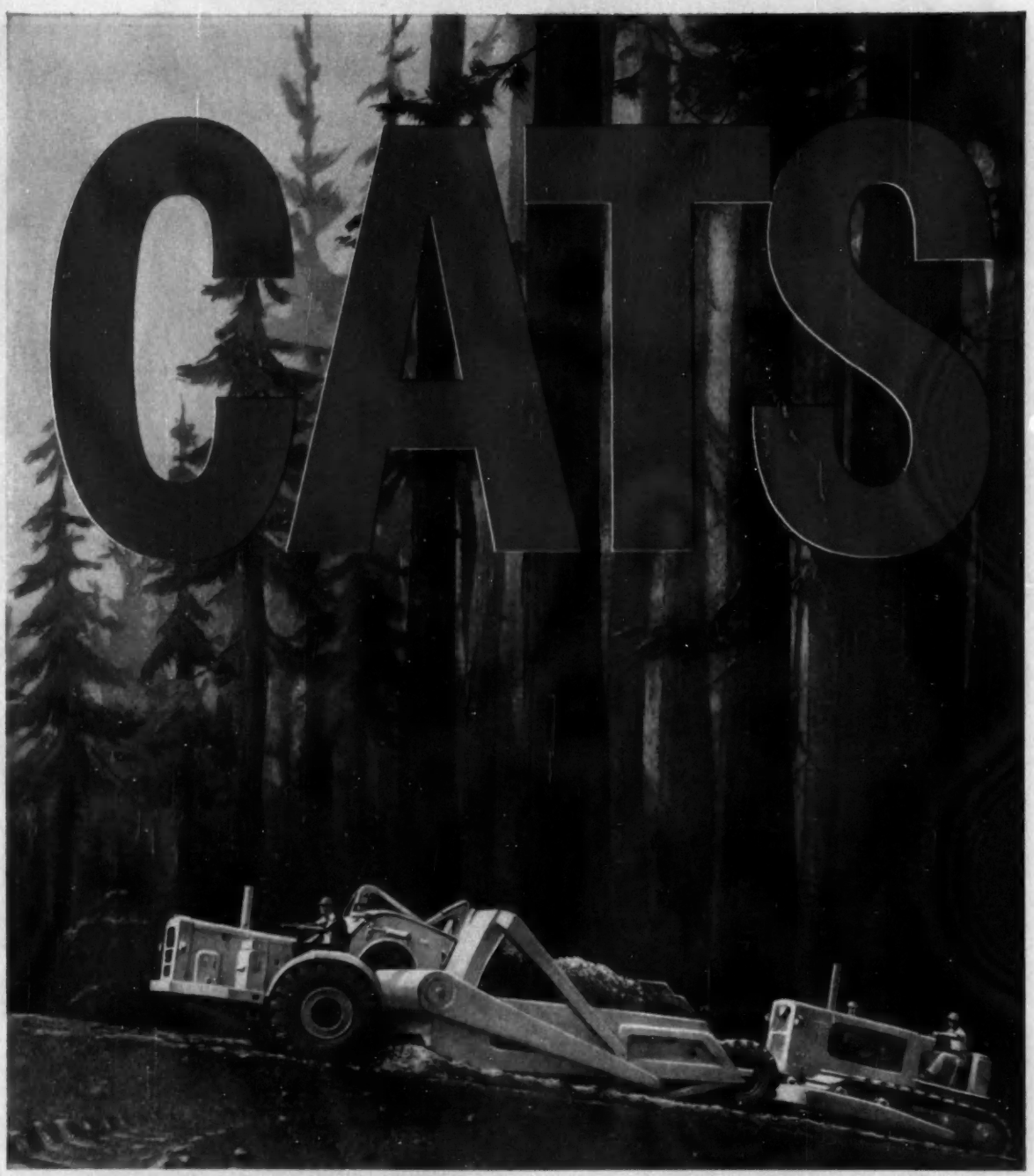

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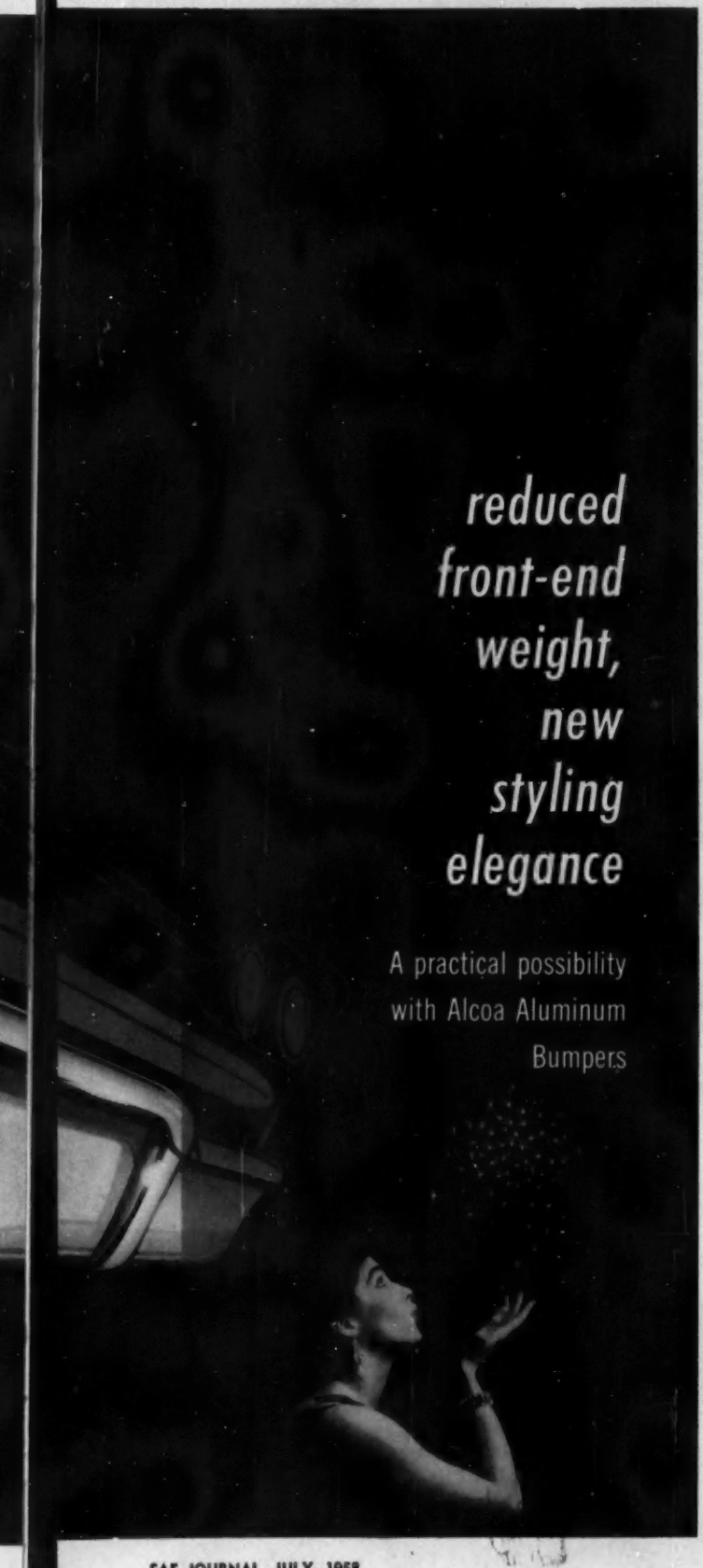

Detroit's designers got no pat answers when they came to Alcoa with a special problem: how to get a lighter, more attractive bumper with no compromise in sturdiness and safety. Alcoa has four standard alloys that might do the job. But we weren't satisfied with that. So, working closely with our automotive colleagues, we developed *five new experimental alloys* that promise important advancements in forming, coloring and texturing bumpers. Here's why the all-aluminum bumper is an imminent "must" on all American passenger cars . . .

Weight Savings—Alcoa's new alloys save half the weight, or more, of steel. They can be increased in thickness and depth to surpass steel in strength and deflection characteristics and still save significant weight. A 30% increase in thickness, for example, can give aluminum nearly four times the energy-absorptive capacity of steel—yet the aluminum will weigh only 45% as much.

Broad Design Flexibility—Extrusions, forgings and combinations of techniques are far more practicable with aluminum. Its easy formability slashes tooling costs, saves much expensive machining. Medallions and other textures and patterns can be embossed right in the metal. Colors, too, can be made part of the metal through the magic process of anodizing.

Strength—Yield strengths of 35,000 psi are possible with Alcoa's new alloys. Even higher strengths are obtainable with some of these special materials.

Corrosion Resistance—Aluminum is highly resistant to the corrosive effects of road salt, noxious fumes, continuous moisture and humidity. Even when scratched, it shows no rust scars. Cleaning with mild soap and water keeps it sparkling new.

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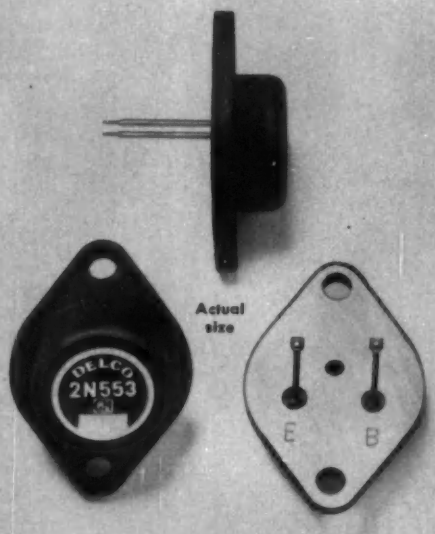

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TYPICAL CHARACTERISTICS T = 25°C unless otherwise specified

Collector diode voltage V_{CB} (V_{EB} = −1.5 volts)	80 volts maximum
Emitter diode voltage V_{EB} (V_{CB} = −1.5 volts)	40 volts maximum
Collector current	4 amps. maximum
Base Current	1 amp. maximum
Maximum junction temperature	95°C
Minimum junction temperature	−65°C
Collector diode current I_{CO} (V_{CB} = 2 volts)	12 μa
Collector diode current I_{CO} (V_{CB} = −60 volts)	0.5 ma
Collector diode current I_{CO} (V_{CB} = −30 volts, 75°C)	0.5 ma
Current gain (V_{CE} = −2 volts, I_C = 0.5 amp.)	55
Current gain (V_{CE} = 2 volts, I_C = 2 amps.)	25
Saturation voltage V_{EC} (I_B = 220 ma, I_C = 3 amps.)	0.3
Common emitter current amplification cutoff frequency (I_C = 2 amps. V_{EC} = 12 volts)	25 kc
Thermal resistance (junction to mounting base)	1° C/watt

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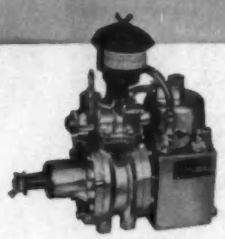

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5. Assembled rotary compressors are hooked up to air lines and operating air pressure is applied for leakage tests. While holding pressure, entire compressor is submerged to determine whether any air is escaping.

6. Every Wagner Rotary Air Compressor is given a rigorous "run-in" test to determine its resistance to overheating and its over-all performance. Running temperatures, vibration, noise and air output are carefully noted and analyzed.

WK58-1A

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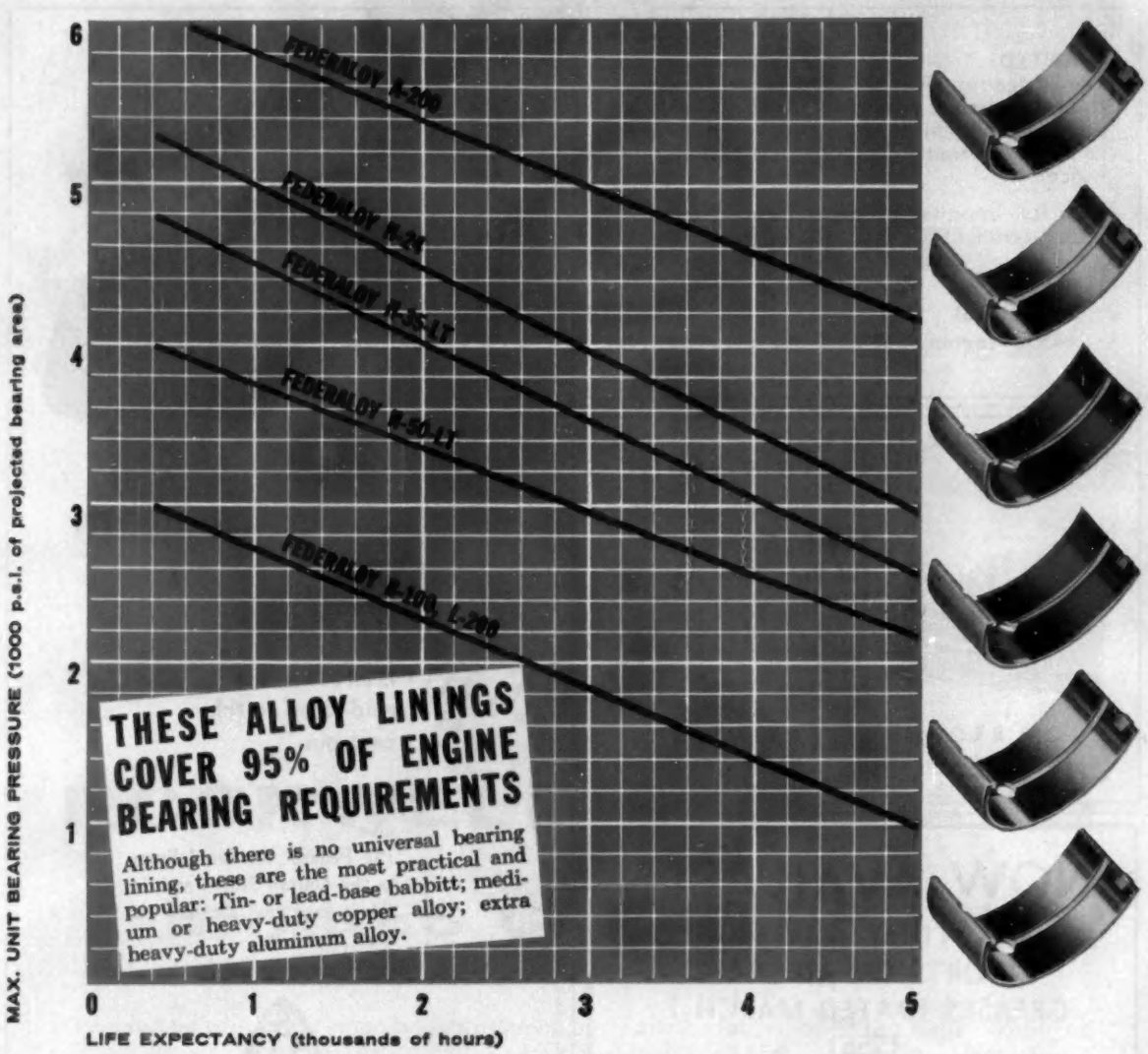

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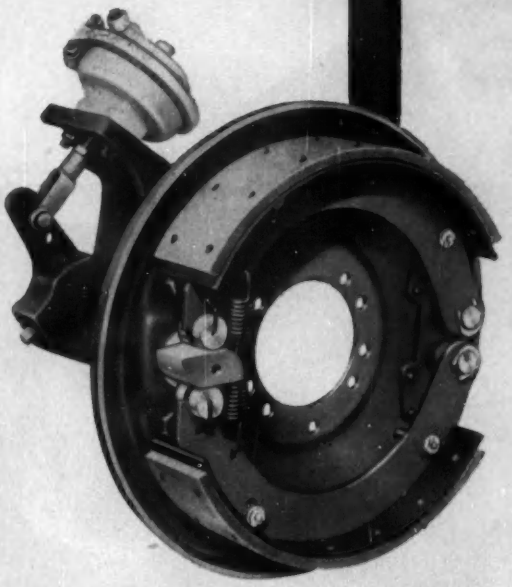

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We're developing bearings and bushings for equipment that DOESN'T EXIST...

For equipment that *might exist some day.* It means preparedness for the future. And for equipment entering the blueprint stage, it means Cleveland Graphite Bronze can offer improved designs and materials *right now.*

As a result, our field engineering teams, working in customers' plants, provide valuable assistance on the problem at hand combined with a sharp awareness of probable future requirements.

In essence, what these teams have to offer you is what they have to back them up: all the resources that have maintained the leadership of Cleveland Graphite Bronze for more than 38 years.

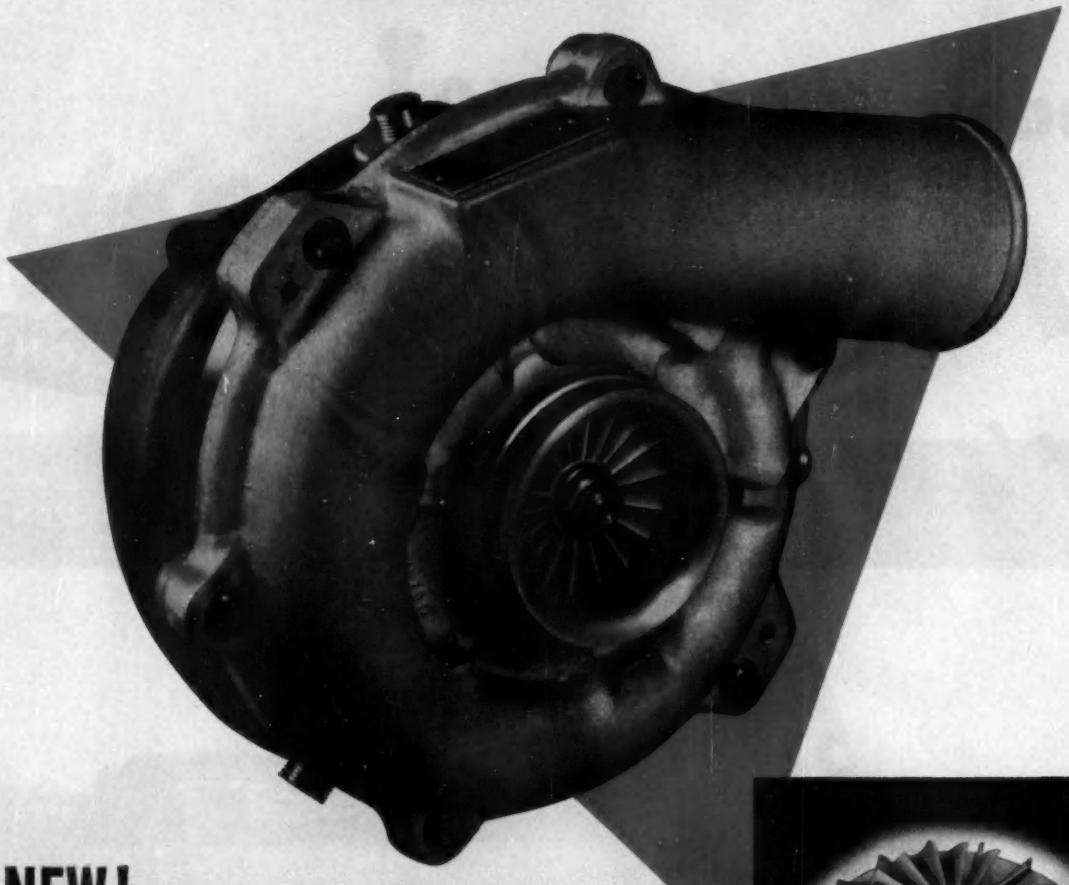
When you're ready for help—remember—Cleveland Graphite Bronze is ready *right now.*

CLEVELAND GRAPHITE BRONZE

17000 St. Clair Avenue • Cleveland 10, Ohio

Detroit
Chicago
New York
Los Angeles

DIVISION OF CLEVITE



NEW! High-pressure supercharging at low rotor speeds with Thompson Turbocharger

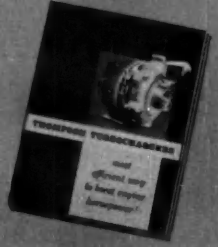
Simple, straight rotor vanes enable the new-design Thompson Turbocharger to produce economical high-pressure blowing of diesel engines even at low rotor speeds. Wear on parts is reduced, maintenance and downtime are kept to a minimum.

In the development labs of the Jet Division, impeller vane contours were developed to make use of Thompson's two decades of experience in high efficiency movement of air and gases.

Other *new* features of Thompson Turbochargers include unique small-diameter shaft and bearing to provide lower shaft surface speeds at equal compression ratios. Bearing and shaft wear is kept to a minimum. In addition, unique Thompson design keeps exhaust heat from traveling to bearings and compressor side of the Turbocharger.

If you build supercharged diesel engines up to 300 horsepower, we can supply a Thompson Turbocharger to provide even more horsepower and fuel economy. If you install diesel engines in trucks or diesel-powered equipment, you'll increase horsepower without increasing engine size by specifying Thompson Turbochargers.

Our sales engineers will help you make the switch to Thompson Turbochargers with practically no redesign of exhaust or intake side. When may they call?



Write today on your company letterhead for Booklet SJ-758, which contains technical data on Thompson Turbochargers for blown diesel engines up to 300 horsepower.

JET DIVISION

Thompson Products, Inc.

Cleveland 17, Ohio

Models R-96, R-960

ROADRANGER® TRANSMISSIONS

New ALUMINUM

the *LIGHTEST* 10-speed transmissions in trucking

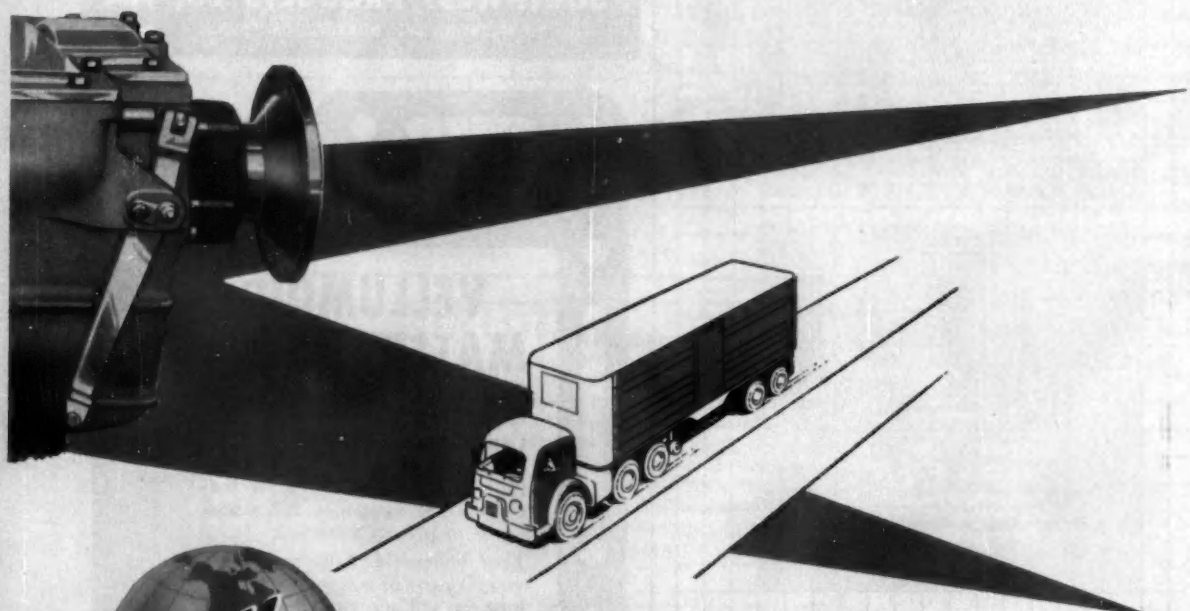
New aluminum housings cut transmission weight by 160 pounds. In addition to this big weight reduction, these 10-speed RoadRangers offer:

- No gear splitting—10 selective ratios, evenly and progressively spaced.
- Easier, quicker shifts—28% steps between ratios.
- One shift lever controls all 10 forward and 2 reverse speeds.
- Engines operate in peak hp range with greater fuel economy.
- Range shifts pre-selected—automatic and synchronized.
- Less driver fatigue—⅓ less shifting.
- Compact space-and-weight-saving economies—the lightest, most compact 10-speed transmissions available.

See your truck dealer now . . . or write Fuller Manufacturing Company for complete details.

160 pounds lighter!

Alloy Clutch Housing • Front Case • Auxiliary Case



More payload per trip... *every trip*
means more profitable tonnage yearly!

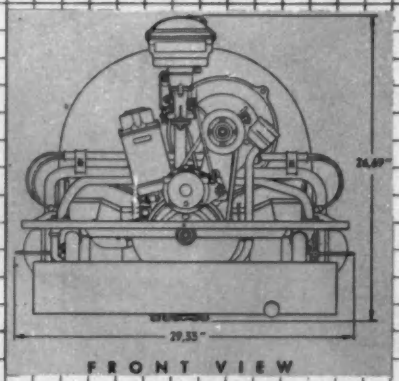
COUNT THE EXTRA PROFITS! The new 10-speed Fuller Models R-96 and R-960 (overdrive in 10th) save 160 pounds in axle loads . . . increase payloads just that much on every trip. Total this extra freight over one year's operations and you'll see why these aluminum-cased RoadRanger Transmissions are the most profitable ever offered the industry!

FULLER MANUFACTURING COMPANY • KALAMAZOO, MICH.

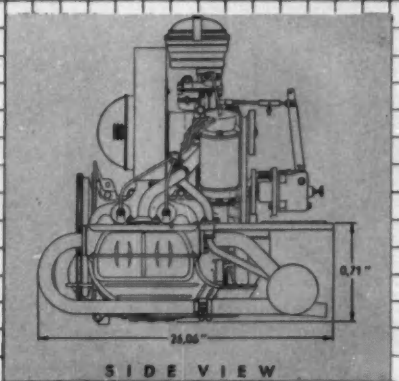
VOLKSWAGEN

Industrial Engine

Four cylinders horizontal opposed
Air cooled 4 cycle
Overhead valves
31 S.A.E. horsepower
at 3000 R.P.M.
Continuous duty
29⅜" wide
26½" long
26½" high
Weight 187 lbs.



FRONT VIEW



SIDE VIEW

IMPORT MOTORS OF CHICAGO, INC.

INDUSTRIAL ENGINES DIVISION

1527 East 71st Street

Chicago 19, Illinois

"MONOBALL"®

Self-Aligning Bearings

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. SAE 58

SOUTHWEST PRODUCTS CO.

1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

VELLUMOID

VELLUMOID MATERIALS . . . for that perfect seal!

Carefully considered gasket applications demand the right gasket . . . Look to Vellumoid for both engineering assistance and a wide range of proven materials.

The Vellumoid Company offers you 50 years of accumulated know-how in solving gasket problems. Our Sales Engineer is glad to work with your engineering groups.

We'll furnish samples for testing on your applications.

THE VELLUMOID COMPANY

Worcester, Massachusetts

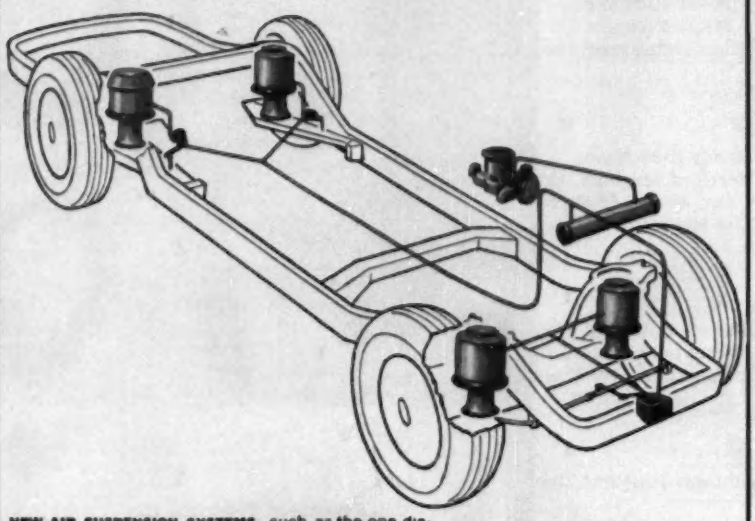
DU PONT

AUTOMOTIVE ENGINEERING

ZYTEL® NEWS

NYLON RESINS

Tubing of Du Pont ZYTEL® overcomes toughest sub-chassis conditions in air suspension and lubrication systems



NEW AIR SUSPENSION SYSTEMS, such as the one diagramed above, use strong tubing of ZYTEL nylon resin.

Tubing of ZYTEL nylon resin is now incorporated in many of the new air suspension systems, because it can take the punishment of tough conditions close to the road. ZYTEL first proved its resistance to petroleum chemicals and high pressures in self-contained lubrication systems for automobiles. So, applying the tubing to air suspension systems was another step forward in design. These lines operate over a wide temperature range, and are very tough and resistant to abrasion.

Tubing made of Du Pont ZYTEL is used with standard fittings, can be color coded for identification and is easily installed without deburring or special tools. ZYTEL has a specific gravity of 1.14—one-seventh the weight of copper. It is impervious to lubricating and hydraulic fluids.

NEW PRINTED CIRCUITS for vehicle control panels use removable lamp sockets molded of black ZYTEL nylon resin. The sockets have excellent dimensional stability, high strength and offer the necessary electrical insulation. Small, intricate parts are often molded of ZYTEL using multi-cavity dies, fast cycles. Injection molding is economical for quantity production. Further economies come from minimum waste of material . . . no need for finishing.

* * *

We're offering a design book that we believe will be useful to you. Check off your needs on the coupon and send it to us.

New Design Manual

—shows you how to apply standard equations in designing with ZYTEL. Gives tables, graphs and sample calculations. Information on loads, stresses, gears, bearings. First aid for *redesign* of parts. Send the coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 377, Du Pont Building, Wilmington 98, Delaware

☐ Please send new manual: **DESIGNING WITH "ZYTEL" NYLON RESIN.**
☐ Please send me additional information on Du Pont ZYTEL nylon resins.
I am interested in evaluating this material for_____

*Name*_____

*Company*_____ *Position*_____

*Street*_____

*City*_____ *State*_____

*Type of Business*_____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

+ INDEX TO ADVERTISERS +

A

AiResearch Mfg. Co. 149
Allegheny Ludlum Steel Corp. 16
Aluminum Co. of America 170, 171
American Society of Tool Engineers 134
American Viscose Corp. 161
Automotive Gear Div., Eaton Mfg. Co. 185

B

Bendix Aviation Corp.
Eclipse Machine Div. 159
Lake Shore Div. 136
Products Div. (General Sales) 24
Bestwall-Certain-teed Sales Corp. 147
Bethlehem Steel Co. 127
Borg & Beck Div., Borg-Warner Corp. 167
Bower Roller Bearing Div., Federal-Mogul-Bower Bearings, Inc. 146
Bridgeport Brass Co. 20
Brooks & Perkins, Inc. 176
Bundy Tubing Co. 156, 157

C

Campbell, Wyant & Cannon Foundry Co. 173
Cleveland Graphite Bronze Co., Div. Clevite Corp. 178
Cleveland Steel Products Corp. 125
Continental Aviation & Engineering Corp. 131
Continental Motors Corp. 186

D

Dana Corp. 153, 154
Delco Radio Div., General Motors Corp. 172
Delco Remy Div., General Motors Corp. 128, 129
Douglas Aircraft Co., Inc. 162
Dow Corning Corp. 140
E. I. du Pont de Nemours & Co., Inc. Plastic Sales 183

E

Eaton Mfg. Co.
Automotive Gear Div. 185
Saginaw Div. 22
Electric Wheel Div., Firestone Tire & Rubber Co. 124
Enjay Co., Inc. 19, 169

F

Federal-Mogul Div., Federal-Mogul-Bower Bearings, Inc. 175
Fuller Mfg. Co. 180, 181

G

Gardner Denver Co. 21
Goodyear Tire & Rubber Co.
Foam Products 13
Metal Products 9
Great Lakes Steel Corp. 15

H

Handy & Harman 158
Hartford Machine Screw Co., Div. Standard Screw Co. 126
The Heim Co. 18

I

Import Motors of Chicago 182
International Nickel Co., Inc. 160
International Packings Corp. 143

J

Johnson Products, Inc. 148

K

Kelsey Hayes Co. 135

L

Luber-Finer, Inc. 3

M

The Mather Spring Co. 12
Mechanics Universal Joint Div., Borg-Warner Corp. 144
Midland-Ross Corp. 145, 166
Monroe Auto Equipment Co. 8

N

National Seal Div., Federal-Mogul-Bower Bearings, Inc. 11
North American Aviation, Inc. 124, 134

O

Oakite Products, Inc. 152
Oldsmobile Div., General Motors Corp. 130
Orschein Lever Sales Co. 168

P

Perfect Circle Corp. Inside Front Cover
Pioneer Aluminum, Inc. 163

R

Reichhold Chemicals, Inc. 164
Republic Aviation 139
Rockford Clutch Div., Borg-Warner Corp. 141
Rockwell-Standard Corp. 177
Ross Gear & Tool Co. Inside Back Cover

S

Saginaw Steering Gear Div., General Motors Corp. 7
Shell Oil Co. 123
Southwest Products Co. 182
Stratoflex, Inc. 150
Sun Oil Co. 4

T

Thompson Products, Inc. Jet Div. 179
Timken Detroit Axle Div., Rockwell-Standard Corp. 151
Timken Roller Bearing Co. Outside Back Cover
The Torrington Co. 155
Tung-Sol Electric, Inc. 14

U

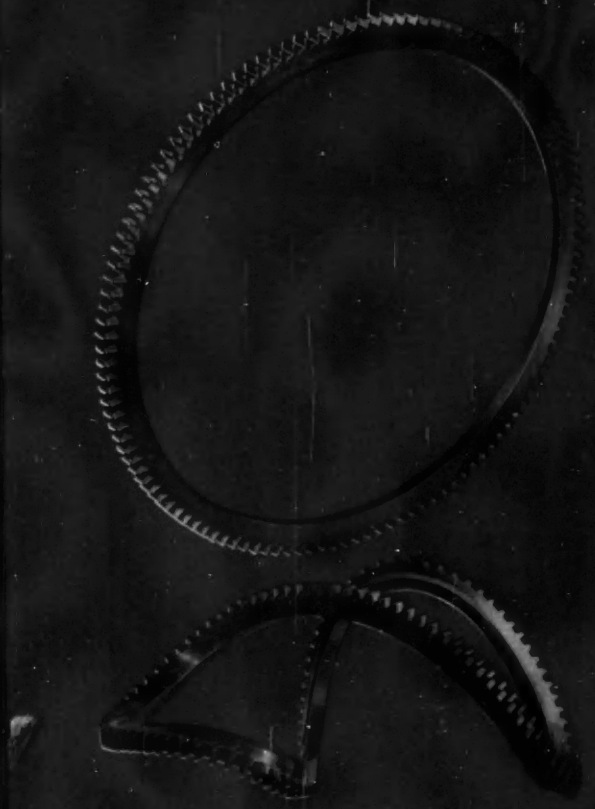
United States Gasket Co. 138
Universal Joint Div., Rockwell-Standard Corp. 165

V

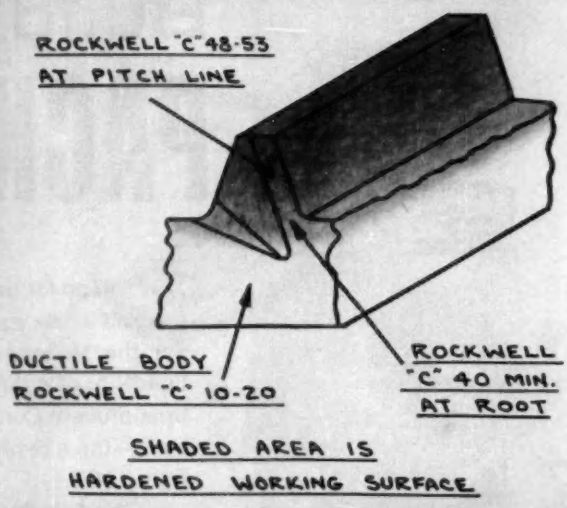
Vellumoid Co. 182

W

Wagner Electric Corp. 174
Waukesha Motor Co. 17
Wausau Motor Parts Co. 132, 133
Weatherhead Co. 142
Western Felt Works 10
Wisconsin Motor Corp. 137



THIN! TOUGH! ...and "tender-hearted"



THE MANUFACTURE of flywheel ring gears poses special problems. Sectional thickness is usually less than three-quarters of an inch. To withstand the impact force of the starter pinion, the gear teeth must be hard. But the gear body itself should be unhardened so that it will conform tightly to the flywheel, and "give" under the stress that might snap a brittle gear.

Note how DOUBLE DIAMONDS are made to be thin, tough, "tender-hearted." The above photo of a gear twisted into a pretzel shape graphically demonstrates ductility. The sketch at right shows three important areas: the wide and deep hardness pattern, the generous area of transition, and the ductile body. These extremes are achieved in DOUBLE DIAMOND Flywheel Ring Gears by controlled selective heat treatment—all essential to flywheel ring gears that provide the best possible performance.

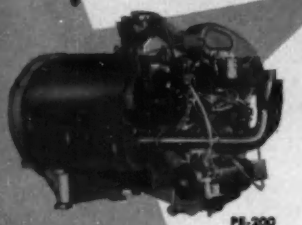
Our Engineering Department will be glad to make constructive suggestions on the design of flywheel ring gears, or on the many other types in which we specialize. Write, phone or wire—depending on the urgency of your need.

EATON

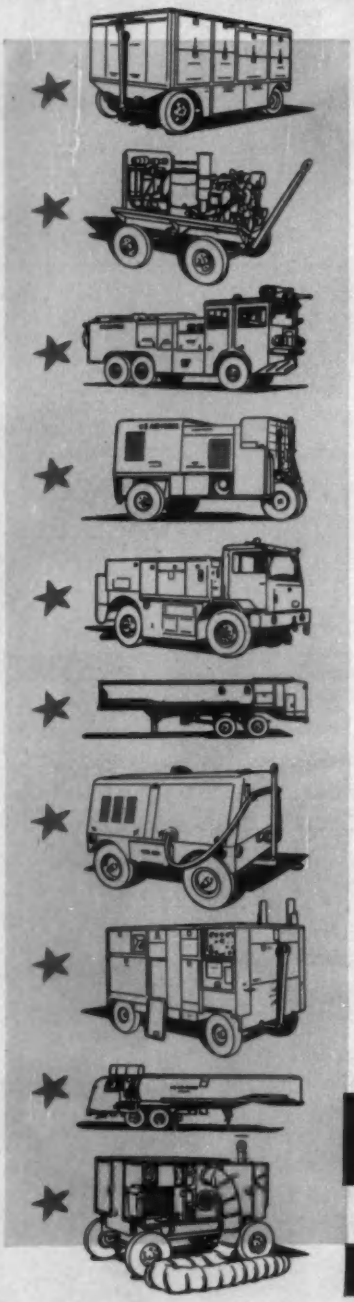
AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

You Hitch Your Ground Support Equipment to a STAR When You Build Around PACKETTE POWER



PE-200
8-cyl. 250 hp.



★ You go far toward clinching complete satisfaction with your product when you design that product around Packette power. For the Military Standard engines known as Packettes (Mil. E6449-A)—Continental-designed, Continental-built, with the time-proved Continental air-cooled aircraft engines as their basis—tap a reservoir of internal combustion experience dating from 1902.

The five Packettes—30 to 250 horsepower—are built for global operation—in the desert, in steaming equatorial jungle, at the pole. They are light and compact, and easy to service in the field. Upkeep is eased by a high degree of parts interchangeability both with other Packette models and with engines of the basic Continental aircraft line, whose service and parts facilities encircle the world.

Packettes are power plants in being—approved for all branches of the Armed Forces,—and in steadily-widening use in ground support equipment of all kinds. If YOUR product's requirement lies within the Packette limits, you too will be ahead with dependable Packette power.

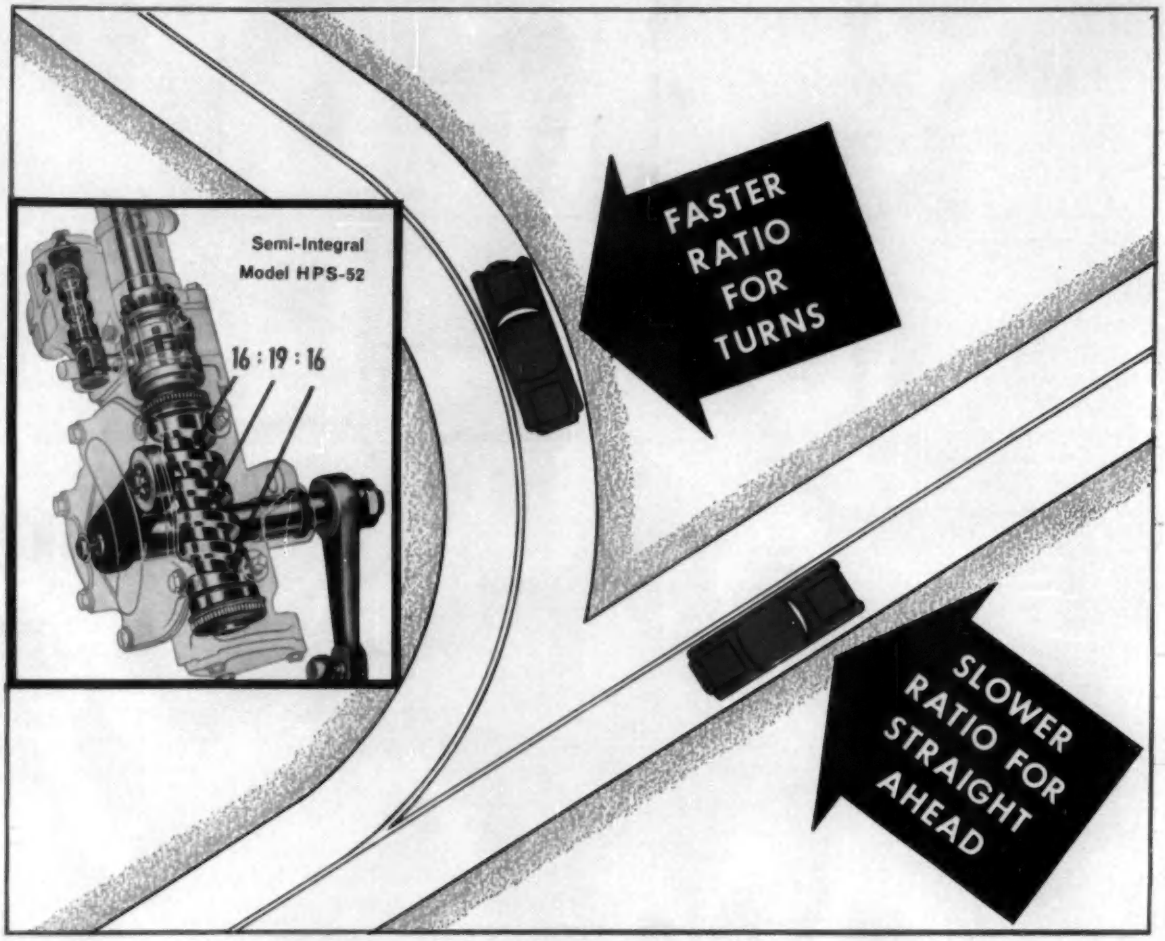
WRITE FOR COMPLETE INFORMATION

Continental Motors Corporation

AIRCRAFT ENGINE DIVISION

MUSKEGON, MICHIGAN

ROSS Variable-Ratio Steering



▶ Faster steering and quicker recovery for *turns!* Slower steering and almost hands-off stability for *straight-ahead!*

▶ These exclusive benefits of Ross variable-ratio manual and power steering help provide *alert steering response* and *greater maneuverability* for vehicles of many different types:

Passenger cars	*Farm Machinery*
Trucks, Buses	*Industrial Equipment*

▶ Why not consider them in terms of *your* steering needs? Ross invites discussion of any steering problem, power or manual, variable or constant ratio.

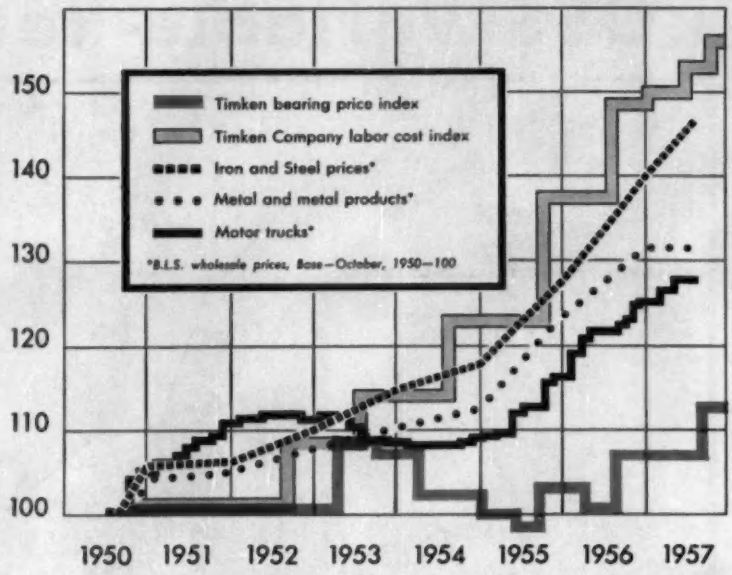
Ross **STEERING**

ROSS GEAR AND TOOL COMPANY, INC. • LAFAYETTE, INDIANA

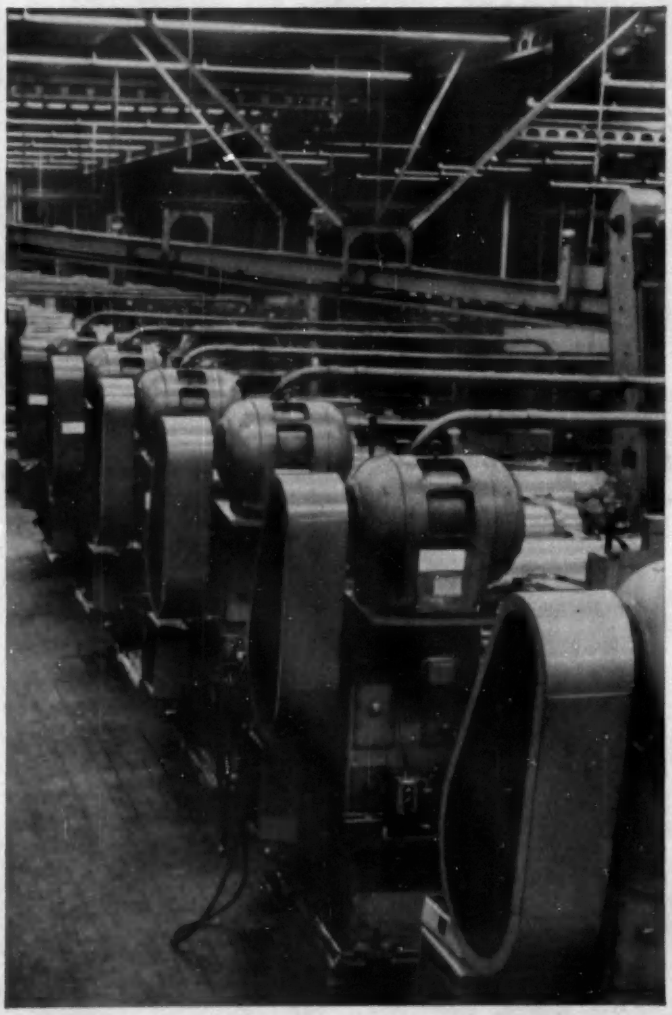
Gemmer Division • Detroit

Here's how truck-makers have helped hold the line on bearing costs

Almost everything a truck-maker buys has shot up in the last few years (see right). But the cost of Timken® tapered roller bearings for trucks has stayed down. Truck-makers themselves helped do it by 1) standardizing on fewer bearing sizes so we could produce them more efficiently and 2) using the new-design Timken bearings wherever they could. These are low-cost, capacity-packed bearings made in standardized sizes by the most modern machinery and methods in the bearing industry.



TOTAL VEHICLE COST OF PINION, DIFFERENTIAL, REAR WHEEL AND FRONT WHEEL BEARINGS



And here's how they can help keep them at rock-bottom

Here's a section of our Bucyrus, Ohio plant that uses revolutionary machines and techniques to produce over 30 million Timken bearings a year. From raw steel to finished bearings without a hand touching them. And we pass the manufacturing savings on to you. These missile age methods can *keep* your bearing costs down if you do two things. 1) Standardize on still fewer Timken bearing sizes for trucks making our production even more efficient. 2) Use more Timken bearings and increase the manufacturing savings by keeping these machines going full-tilt. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

BEAT INFLATION WITH... STANDARDIZATION

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS